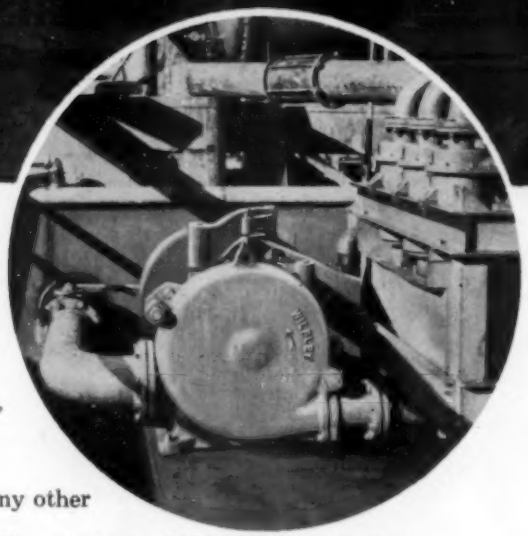
MINING
engineering

WILFLEY SAND PUMPS

HELP CREATE LOWER DRILLING COSTS



The multiple cyclone unit, used in this oil drilling operation for removing sand and abrasive solids from drilling muds, makes possible 20% faster drilling, increased bit footage, 25% longer runs, reduced mud pump maintenance and many other cost-saving advantages. A vital factor in the economy of this operation is the Wilfley Sand Pump which provides: maintained high efficiency; continuous, trouble-free operation without attention; simple and speedy replacement of long-wearing parts.

Another example of Wilfley's contribution to lower operating costs throughout industry.

Wilfley Sand Pumps
"Companions in Economical Operation"
Wilfley Acid Pumps

Individual Engineering on Every Application. Write, wire or phone for complete details.

A. R. WILFLEY and SONS, INC.

DENVER, COLORADO, U.S.A. • NEW YORK OFFICE: 122 EAST 42nd ST., NEW YORK CITY 17

EDITORIAL STAFF

Editorial Director: Rixford A. Beals

Associate Editor: Donald Tone

Assistant Editors: M. E. Sherman, H. Nielsen, H. Witzling

Production Editor: M. Snedeker

Eastern Advertising Manager: Thomas G. Orme, 29 W. 39th St., New York

Mid-Western Advertising Manager: Bob Wilson, Millard Ave., Fox River Grove, Ill.

Western Advertising Representatives: McDonald-Thompson, 625 Market St., San Francisco 5, Calif.

Production Manager: Grace Pugsley

Asst. Prod. Manager: W. J. Sewing

SOCIETY OF MINING ENGINEERS

President: Elmer A. Jones

Past-President: Will Mitchell, Jr.

Treasurer: R. B. Ladoo

Secretary: Arnold Buzzalini

Editorial Board: H. C. Weed (Chairman), D. W. Scott, J. W. Woomer, R. B. Ladoo, A. Buzzalini, Advertising Director, R. A. Beals.

AIME OFFICERS

President: Grover J. Holt

Past-President: C. E. Reistle, Jr.

President-Elect: A. B. Kinzel

Vice-Presidents: E. C. Babson, W. A. Dean, L. E. Elkins, J. L. Gillson, W. W. Mein, Jr., Roger V. Pierce

Treasurer: C. R. Dodson

Secretary: Ernest Kirkendall

AIME STAFF

Asst. Secretaries: J. B. Alford, H. N. Appleton, E. J. Kennedy, Jr., R. W. Shearman

Field Secretary & Asst. Secretary: R. E. O'Brien, 707 Newhouse Bldg. Salt Lake City 1, Utah

Asst. Treasurer: P. J. Apol

The AIME also publishes **Journal of Metals** and **Journal of Petroleum Technology**

Published monthly by the American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc., 29 West 39th St., New York 18, N. Y. Telephone: PEnnsylvania 6-9220. Subscription $8 per year for non-AIME members in the U. S., & North, South, & Central America; $10 foreign; $6 for AIME members, or $4 additional in combination with a subscription to "Journal of Metals" or "Journal of Petroleum Technology" Single copies, $.75; single copies foreign, $1.00; special issues, $1.50. The AIME is not responsible for any statement made or opinion expressed in its publications. Copyright 1957 by the American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc Registered cable address, AIME, New York. Indexed in Engineering Index, Industrial Arts Index, and by The National Research Bureau. Second class mail privileges authorized at New York, N. Y., and additional entry established at Manchester, N. H. Number of copies of this issue 14,600

ABC

MINING engineering

VOL. 9 NO. 4 APRIL 1957

COVER

Cover artist Herb McClure illustrates one of the basic steps in a mining operation. For *A New Look at Mining*, turn to page 434.

KNOW YOUR SOCIETY

Society Officers and Committees Announced 465

ARTICLES

Quality Control in Selective Mining of Magnesite C. Martin and H. P. Willard 425

A New Look at Mining E. R. Borcherdt 428

Open Pit Loading Analysis for Better Cost Control P.-E. Mercier 434

The Resin-in-Pulp Method for Recovery of Uranium R. F. Hollis and C. K. McArthur 442

Crestmore Makes a Change R. H. Wightman, P. B. Nalle, and C. D. Chandler 450

Sinking Large Diameter Mine Shafts by Rotary Drilling V. Zeni and T. N. Williamson 455

New Horizons for Lithium P. E. Landolt 460

FEATURES

Personnel	382	Society News	465
Books	386	AIME News	466
Manufacturers News	395	Personals	470
Reporter	403	Professional Services	478
Mining News	407	Coming Events	480
Trends	418	Advertisers Index	480

Drift: C. E. Reistle, Jr., Reports on State of the Institute 422

PERSONNEL

THE following employment items are made available to AIME members on a non-profit basis by the Engineering Societies Personnel Service, Inc. (Agency) operating in cooperation with the Four Founder Societies. Local offices of the Personnel Service are at 8 W. 40th St., **New York 18;** 100 Farnsworth Ave., **Detroit;** 57 Post St., **San Francisco;** 84 E. Randolph St., **Chicago 1.** Applicants should address all mail to the proper key numbers in care of the New York office and include 6c in stamps for forwarding and returning application. The applicant agrees, if placed in a position by means of the Service, to pay the placement fee listed by the Service. AIME members may secure a weekly bulletin of positions available for $3.50 a quarter, $12 a year.

MEN AVAILABLE

Field Representative, D.Sc. in mining engineering, 55; about 15 years practical experience in geological exploration in ten different countries. Some experience mining and milling practices. Considerable experience under-developed countries in tropical areas of Latin America and Far East. Fluency in four languages. About ten years experience mineral economics and planning. Location, immaterial. M-309.

Mining Engineer or Assistant Mine Manager, B.S. in mining engineering, 28. Mine foreman in 350-tpd Pb-Zn-Cu mine in central Peru for about three years. Prefer northeastern United States. M-310.

Mining Engineer, B.A., 40. Twenty years experience metal mining, construction of mills and concentrators, exploration and development of mining properties in U. S. and South America. Prefer consulting and mine examination work, preferably western U. S. or South America. M-312.

Mine Superintendent Manager, B.S.E.M., 53, graduate mining engineer. Twenty-six years experience foreign and domestic mining; mine operation; management, mining geology and exploration; examination and reports. Prefer U. S. or foreign. M-313.

Manager, General Manager, Consultant, E.M. degree, 51. Thirty years experience as engineer, manager, staff consultant, exploration, development, production, some manufacturing, large, small, and medium-sized companies. Presently executive with multi-plant nationwide organization. Registered professional engineer. Prefer Midwest, West, Southwest, East. M-314.

Manager of Exploration or Senior Geologist, degree, geological engineer (mining), 35. Two years supervising exploration program; three years experience as exploration geologist and evaluation engineer; one year experience as junior engineer; five years experience mining and mine engineering, mining, mine sampling, mine and surface surveying, ore reserve calculations in lead, zinc, copper, and uranium. Prefer western U. S.; will go to Mexico, Central America, South America for right job. M-315-Detroit.

POSITIONS OPEN

Geologist or Mining Engineer, 40 to 50, to head up an exploration on a Bolivian concession. Should have worked in South America and speak Spanish. Salary, $12,000 to $15,000 year. F4644.

Assistant Mine Superintendent, mining engineering graduate, with at least five years open pit and some underground experience, to supervise continuous operations covering stripping, transportation, warehousing, and general mining engineering. Salary, $7800 a year. Location, Caribbean area. F4602.

Mining Engineers. b) *Assistant Mine Superintendent,* for mine. c) *Division Mine Foreman.* Location, Mexico. F4604.

METALLURGIST-ASSISTANT MILL SUPERINTENDENT for 400-700 ton lead-zinc-copper flotation plant located in Colorado. Please reply stating experience and qualifications to:

Box 7-ME AIME
29 West 39 Street New York 18, N. Y.

SCRAP TUNGSTEN CARBIDE ROCK BIT INSERTS

are regularly purchased by Macro Tungsten Refinery. For our quotation F.O.B. shipping point, write P.O. Drawer 440, Port Coquitlam, B.C., Canada.

KENNAMETAL* Carbide Bits

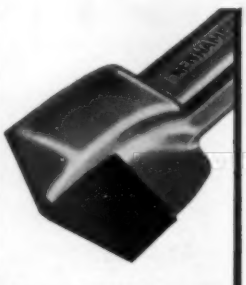
stay sharp longer

...reduce costs

Kennametal produces the world's most extensive line of carbide-tipped mining bits and accessories, engineered and designed for economical service in any drilling condition. Tough Kennametal tips stay sharp longer, take harder knocks than any other tungsten carbide. Kennametal representatives—all men with years of actual mining experience—will recommend the right bit for the job and demonstrate proper application, in the mine.

Kennametal Drill Bits are available in more than 20 tip and shank designs for low-cost drilling in coal, clay, slate, shale, soda ash and similar formations.

Short, sturdy prongs enable the Kennametal RD Bit to drill harder and tougher material than is possible with standard two-prong bit designs.



Kennametal FDH bits, with their large solid carbide blades, drill the hardest formations that can be rotary drilled.

Look for the name of your Kennametal representative in the yellow section of your phone book, or on the back of your Kennametal Price Book—or, write direct to KENNAMETAL INC., Mining Tool Division, Bedford, Pa.

**Trademark*

B-11414

INDUSTRY AND KENNAMETAL ...Partners in Progress

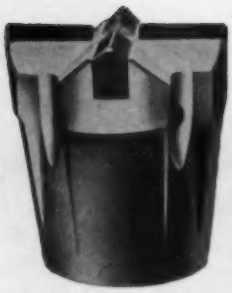
KEEP PRODUCTION ROLLING *with help like this . . .*

- **EXCLUSIVE "ROLL-AWAY" MOLDBOARD . . . moves tough dirt fast**
- **NEW TOGGLE-TYPE CONTROL . . . kick-free in the rough . . . pinpoint accuracy**
- **HIGHEST AXLE AND THROAT CLEARANCE in its class . . . for better handling of biggest loads**
- **TOUGH TUBULAR FRAME . . . shock-absorbing strength down the middle**
- **BOX-SEAT COMFORT AND VISIBILITY . . . satisfied operators . . . more and better work done on all grading jobs**

ROLL-AWAY is an Allis-Chalmers trademark

These are five of many reasons why Allis-Chalmers FORTY FIVE motor graders are showing up in more and more mining and quarrying operations. They are precisely what the dirt-moving specialists ordered . . . ready now to handle haul road construction and maintenance easily, smoothly. Allis-Chalmers, Construction Machinery Division, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS *Engineering in Action*

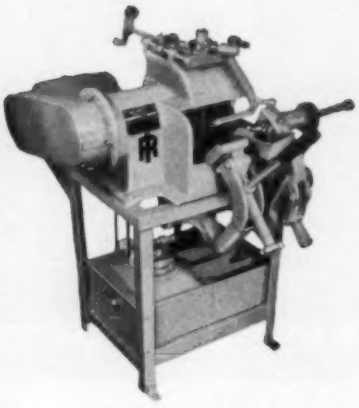
CARSET  JACKBITS

are PRECISION MADE

for HIGHEST PERFORMANCE

Maintain That Performance
by resharpening with
the NEW JC-3 JACKBIT GRINDER

- ▲ Grinds cutting faces to precisely correct profile for maximum drilling efficiency.
- ▲ Grinds bit gage to proper clearance.
- ▲ Eliminates waste of over-grinding.
- ▲ Greatly multiplies operator output.
- ▲ Available with electric, air or gasoline engine drive.



JC-3 Electric Drive Grinder

TO MAINTAIN the unequalled drilling speed of a NEW Ingersoll-Rand Carset Jackbit—and get maximum feet of hole from each bit — resharpening should be done to close tolerances and without unnecessary waste of the cutting material.

All of these requirements are met to excellent advantage with the new JC-3 Jackbit grinder — far more quickly, easily and accurately than by hand grinding methods. Ask your I-R representative for complete information on this time-saving, cost-saving machine. Or send for a copy of Bulletin 4187.

Ingersoll-Rand

11 Broadway, New York 4, N. Y.

COMPRESSORS • TURBO-BLOWERS • ROCK DRILLS
AIR TOOLS • CENTRIFUGAL PUMPS • CONDENSERS
GAS AND DIESEL ENGINES

15-518

An Introduction to Electrostatic in September 1955, are presented in

inside story of a longer grind

Moly-Cop is hard and tough to the core...

A look inside this Moly-Cop ball shows a uniform, fine grain structure extending to the core. It is the result of special alloying, forging and heat treating that provides a hardness and toughness best suited to grinding needs. This is why you can expect a long, economical grind from Moly-Cop balls. It's the big reason why *Moly-Cop* balls have become the *STANDARD OF COMPARISON AROUND THE WORLD.*

SHEFFIELD

ARMCO®

MOLY-COP

COPPER-MOLYBDENUM-ALLOY

Grinding Balls

SHEFFIELD DIVISION

ARMCO STEEL CORPORATION

SHEFFIELD PLANTS: HOUSTON • KANSAS CITY • TULSA

EXPORT REPRESENTATIVES, THE ARMCO INTERNATIONAL CORPORATION, MIDDLETOWN, OHIO

BOOKS

ORDER THE FOLLOWING BOOKS THROUGH AIME—Address Irene K. Sharp, Book Dept. Ten percent discount given whenever possible.

Lectures on Rock Magnetism, by P. M. S. Blackett, *The Weizmann Science Press of Israel,* 131 pp., $5.00, 1956.—This book is a discussion of the use of magnetic data to trace the history of the earth's magnetic field, and a review of recent studies relevant to the earth's field and to the movement of land masses.

An Introduction to Electrostatic Precipitation in Theory and Practice, by H. E. Rose and A. J. Wood, *Constable & Co. Ltd.,* 166 pp., $2.80, 1956.—This short monograph presents a critical review of the present knowledge of the subject based on the authors' research. Basic electrical theory, and the efficiency, design, construction, and problems of precipitators are covered. It is intended for the practical man concerned with gas cleaning, as well as for the student.

Deformation and Flow of Solids, edited by R. Grammel, *Springer-Verlag,* 324 pp., approx. $9.38, 1955.—These papers from the International Union of Theoretical and Applied Mechanics, Colloquium Madrid, held in September 1955, are presented in three sections devoted to dislocations and plasticity; nonlinear elasticity; and viscoelasticity and relaxation. Specific topics dealt with include dislocations in crystals, brittle fracture in metals, elastic deformations and cavitation damage.

Flotation, by A. M. Gaudin, *McGraw-Hill Book Co. Inc.,* 2nd ed., 572 pp., $12.50, 1957.—In this revised edition, new material has been added in the areas of crystal chemistry, fluid mechanics, solution chemistry, and the interplay of these phenomena on the flotation process. Dr. Gaudin, AIME Richards Award recipient, has attempted to present flotation technology to facilitate intelligent control by engineers, and to raise scientific questions as yet unsolved concerning the art.

Operating Ideas for Small Mines, by K. S. Stout, *Montana Bureau of Mines and Geology,* 81 pp., $1.00, 1956.—This is a concise, practical guide for the prospector and small-mine operator containing suggestions concerning drilling, blasting, timbering, and estimating development and mining costs. Special attention is devoted to equipment for a prospect or small mine, including home-made equipment. Diagrams, plates and photographs supplement the text.

Clay and Clay Minerals, edited by Ada Swineford, *National Academy of Sciences—National Research Council,* Pub. No. 456, 434 pp., $6.00, 1956.—The 47 papers in this volume are the proceedings of the Fourth National Conference on Clays and Clay Minerals held in October 1955. Their subject matter comprises soil physics, soil mechanics, mineralogy, ceramics, crystallography, colloid chemistry, and geology. Included are seven reports from scientists abroad on activities in clay mineralogy and technology outside the U. S. Illustrations, photographs and charts supplement the text.

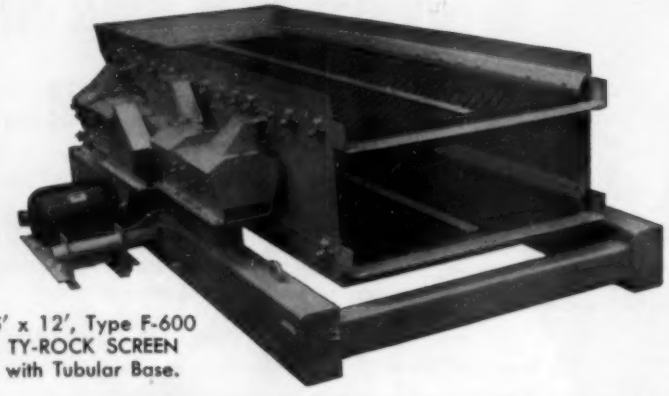
Please Order These Publications from the Publishers

Theophrastus on Stones, by E. R. Caley and J. F. C. Richards, *Ohio State University Press,* Columbus, 10, Ohio, 238 pp., $6.00, 1956.—The first modern translation of this work, it represents the earliest known scientific study of mineral substances and artificial products derived from them. Included are the Greek text, a translation and a detailed commentary.

International Classification of Hard Coals by Type, *United Nations Publications,* United Nations, New York,

(Continued on page 390)

FOR PROFITABLE SCREENING USE



5′ x 12′, Type F-600 TY-ROCK SCREEN with Tubular Base.

TYLER VIBRATING SCREENS AND TYLER WOVEN WIRE SCREENS

There is a Tyler Vibrating Screen for every sizing and dewatering job. Tyler Screens are noted for the huge tonnages handled with top efficiency and low cost per ton.

Tyler Woven Wire Screens are made in all meshes and metals in over 10,000 different specifications. Ton-Cap and Ty-Rod Screens with the long-slot openings provide the greatest capacity for a given discharge area.

THE W. S. TYLER COMPANY
CLEVELAND 14, OHIO
Manufacturers of Woven Wire Screens and Screening Machinery

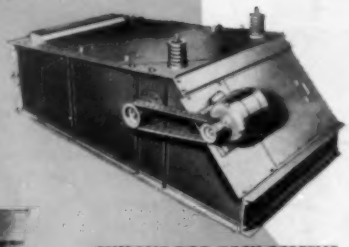
From Scalping to Fine Screening . . .

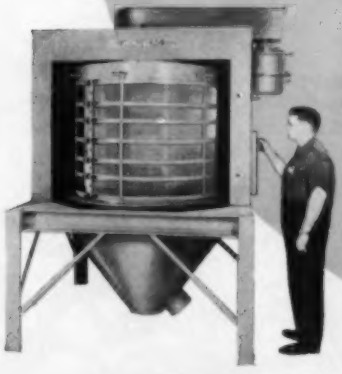
SYMONS VIBRATING BAR GRIZZLIES for heavy duty large capacity primary scalping where clear spacings of 1½" and larger are permissible. Up to 500 tph, handling feeds ranging to 30" and larger.

SYMONS SCREENS

meet production demands for the MINING INDUSTRY

SYMONS VIBRATING ROD GRIZZLIES for heavy duty big capacity scalping. Up to 500 tph for feeds up to 12". Ideal for scalping operations requiring relatively coarse separations in the range between 1" to 4".





SYMONS ROD DECK SCREENS employ a highly efficient screen deck utilizing individual replaceable steel rods. Features low screening cost — big capacity — long life — ideal for moist and sticky materials.

SYMONS V-SCREENS give unequalled high capacity for sharp, single cut, wet or dry separations, especially in the finer sizes. This high capacity, sharp separation is the result of centrifugal force—an exclusive Symons V-Screen feature.

Symons Vibrating Grizzlies and Screens are playing an increasingly important role in the efficient processing required in producing big tonnages of ores and minerals. From heavy duty scalping operations on through fine screening, more and more leading producers are depending upon Symons screens to do a better separation job at lower cost per ton.

These quality grizzlies and screens have gained an enviable reputation for dependability and efficiency throughout the mining industry . . . and are backed by the same high standards of accuracy, workmanship and progressive engineering that is used in the manufacture of *all* Nordberg Machinery.

Mail the coupon for further details.

SYMONS . . .
A REGISTERED NORDBERG TRADEMARK KNOWN THROUGHOUT THE WORLD.

NORDBERG MFG. CO., Milwaukee, Wisconsin

NORDBERG MACHINERY **NORDBERG** SYMONS SCREENS NORDBERG

MACHINERY FOR PROCESSING ORES and INDUSTRIAL MINERALS

NEW YORK • SAN FRANCISCO • ST. LOUIS • DULUTH • WASHINGTON
TORONTO • MEXICO, D.F. • LONDON • JOHANNESBURG

Mail this Coupon Today!

ME

Nordberg Mfg. Co., Milwaukee, Wisc.

Send literature on SYMONS: ☐ Bar Grizzlies; ☐ Rod Grizzlies; ☐ Rod Deck Screens; ☐ V-Screens

Name_____

Company_____

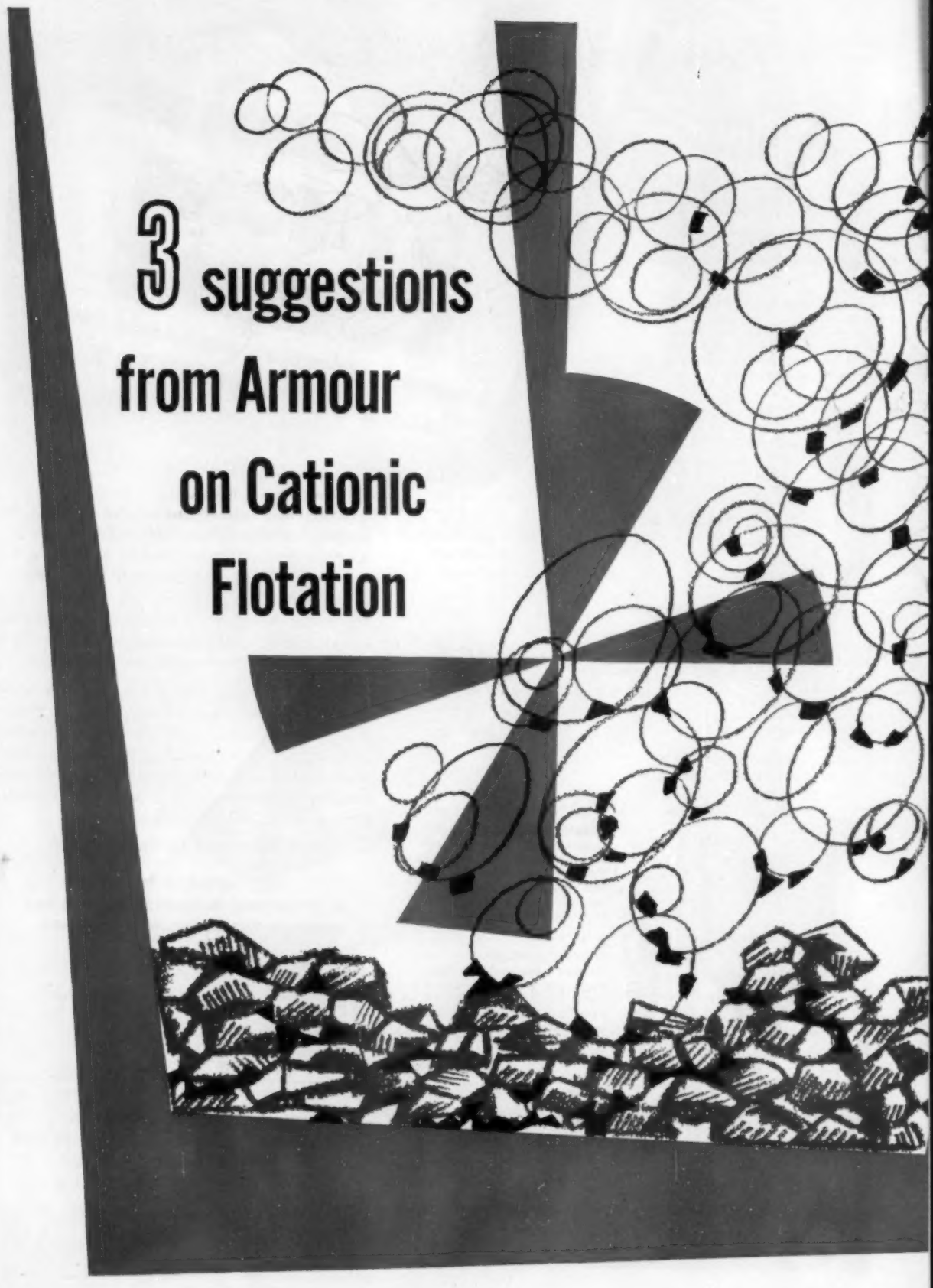
Address_____

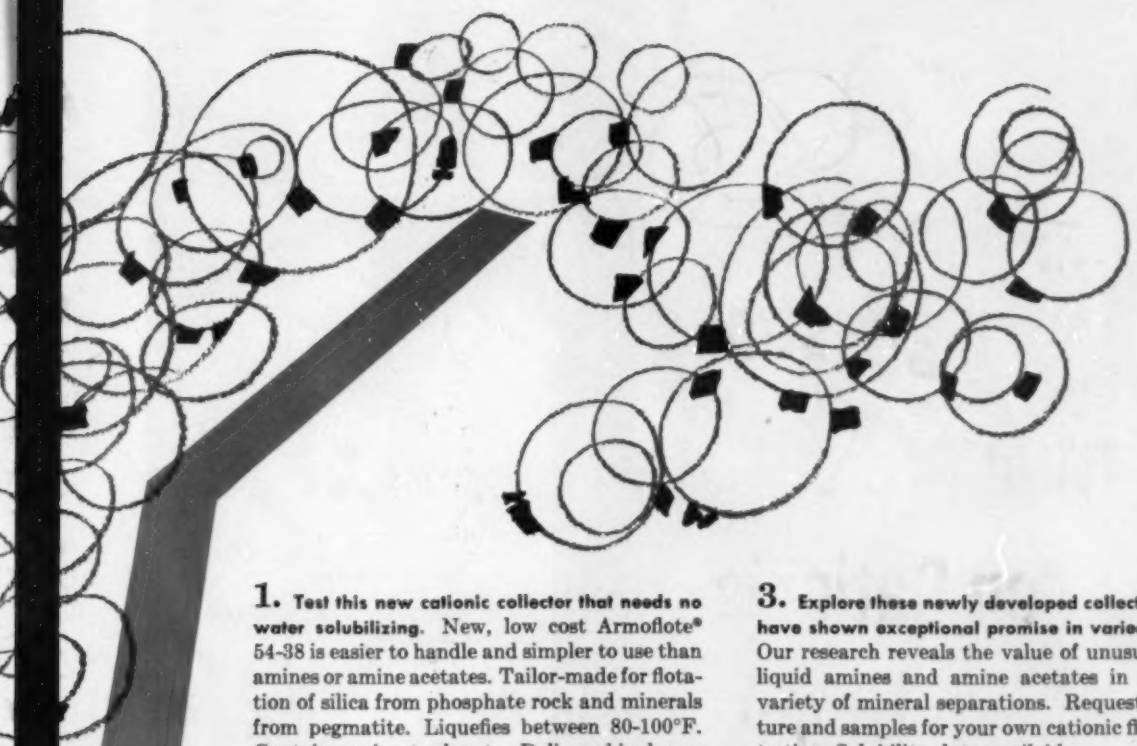
City_____ Zone____ State_____

S456

© 1956, Nordberg Mfg. Co.

3 suggestions from Armour on Cationic Flotation





1. Test this new cationic collector that needs no water solubilizing. New, low cost Armoflote® 54-38 is easier to handle and simpler to use than amines or amine acetates. Tailor-made for flotation of silica from phosphate rock and minerals from pegmatite. Liquefies between 80-100°F. Contains no inert solvents. Delivered in drums or tank cars and *can be blended with secondary collector or frother!* Stores indefinitely or can be used immediately. Send for sample and observe its greater tolerance to slimes and hard water.

2. Investigate the high quality performance of Armacs® in floating silica from iron oxides. The ore in the following typical test was a Mesabi taconite, a mixture of slatey and cherty taconites, holding magnetic iron (17.0 parts) and non-magnetic iron (15.7 parts), the remainder mostly silica. Grinding to 95% minus 100 mesh produced liberation. Desliming was necessary. Iron depressant was starch. Pulp pH: 10-11.

Lbs.	Lbs.	% Fe			Iron Recovery
Armac CD	Frother	Silica Conc.	Middlings	Tailings	Based on original ore
0.80	0.20	6.27	29.62	59.9	77.9

Our flotation experts will be pleased to discuss your iron oxide flotation problems with you.

3. Explore these newly developed collectors that have shown exceptional promise in varied fields. Our research reveals the value of unusual new liquid amines and amine acetates in a wide variety of mineral separations. Request literature and samples for your own cationic flotation testing. Solubility data available.

Specifications of amine acetates (representative lots)

	Armac O	Armac OD
Iodine value	72.7	69.4
Primary amine acetate	89.6	98.5
Secondary amine acetate	6.3	2.0
Neutralization	99.0	96
Moisture	0.73%	0.89%
Cloud point	82°F	98°F
Pour point	40°F	65°F

The corresponding amines (Armeens® O and OD) are available for testing purposes. Request descriptive literature and sample.

• • •

Armour Cationic chemicals increase your recovery of the following minerals: *Amblygonite, Spodumene, Ilmenite, Phosphate, Barite, Beryl, Feldspar, Fluorspar, Hematite, Mica, Potash, Salt, Silica Vermiculite.*

ARMOUR

Leader In Progressive Fatty Acid Chemistry

©Armour Chemical Division • Chicago 9, Illinois

For added suggestions, booklet on flotation, and product data— SEND THIS COUPON!

Armour Chemical Division
1355 West 31st Street • Chicago 9, Ill.

☐ Send specific information on:_____

☐ Send testing sample of_____

☐ Send Cationic Flotation booklet

M 4

Name_____ Title_____

Firm_____

Address_____

City_____ Zone_____ State_____

(Continued from page 386)

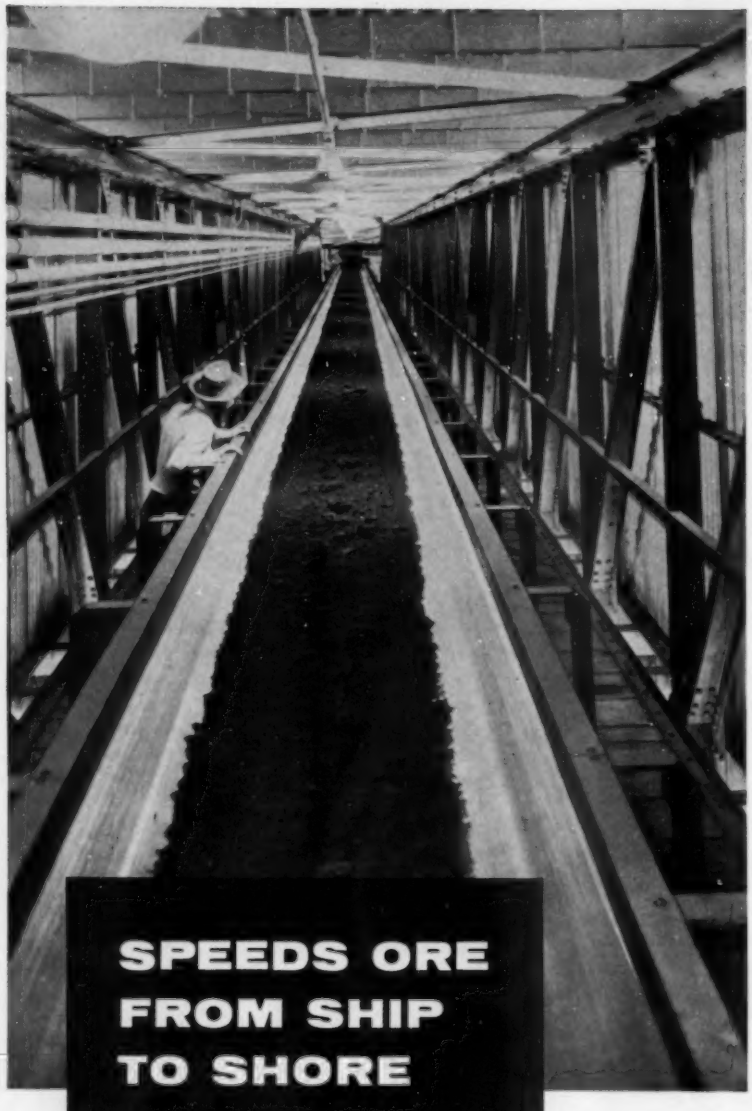
56 pp., 50¢, 1956.—This report describes the procedure for accurate identification and statistical grouping of hard coals by the international classification system. It provides a common language for producers, traders, and users of hard coal, based on the best features of the individual systems, and should facilitate international trade as well as encourage efficient utilization. A bilingual edition, English-French, is available. Tables and charts are included.

Coal Resources of the Upper Part of the Allegheny Formation in Ohio, Report of Investigations No. 29, by R. A. Brant, *The Ohio Div. of Geological Survey,* Orton Hall, Ohio State University, Columbus 10, Ohio, 68 pp, 50¢, 1956.—This is the fourth report on Ohio coal resources prepared by the division. It comprises sections on geology, characteristics of the coal mining history, and estimation and description of coal reserves by county. Illustrations and tables are included.

Bibliography of New Mexico Geology and Mineral Technology, 1951-1955, by C. F. and J. H. Schilling, Bulletin 52, *State Bureau of Mines and Mineral Resources,* Campus Station, Socorro, N. M., 84 pp., $2.00, 1956.—This volume is a supplement to Bulletin 43 and includes some references published before 1951 but not cited in the previous bibliography. The listing includes published and unpublished material that contains useful information concerning the geology of the area. An index arranged under 13 major headings comprises the second part.

How to Select an Air Compressor of the Right Size and Type, *Air Compressor Research Council,* 27 E. Monroe St., Chicago 3, 12 pp., 50¢, 1956. —This booklet presents a method of selecting an air compressor of the right type and size for specific requirements. It includes a discussion of air compressor ratings, displacement and *free air,* volumetric efficiency, types of air compressors, and types of operation, with charts, installation recommendations, maintenance instructions and an explanation of compressed air terminology.

Some Applications of Geophysical Methods to Geological Problems in the Gold Coast, by L. O. Gay and M. Kosten, Bulletin No. 21, *Gold Coast Geological Survey,* P. O. Box 98, Saltpond, Gold Coast, 37 pp., approx. $1.17. 1956.—This is a collection of some of the more interesting results of geophysical investigation performed in the past few years. Subjects include a magnetic variometer survey north of Nanwa Gold Mine and the geological interpretation of some electrical resistivity depth probe curves from gneiss areas in the Gold Coast. Charts and maps supplement the text.

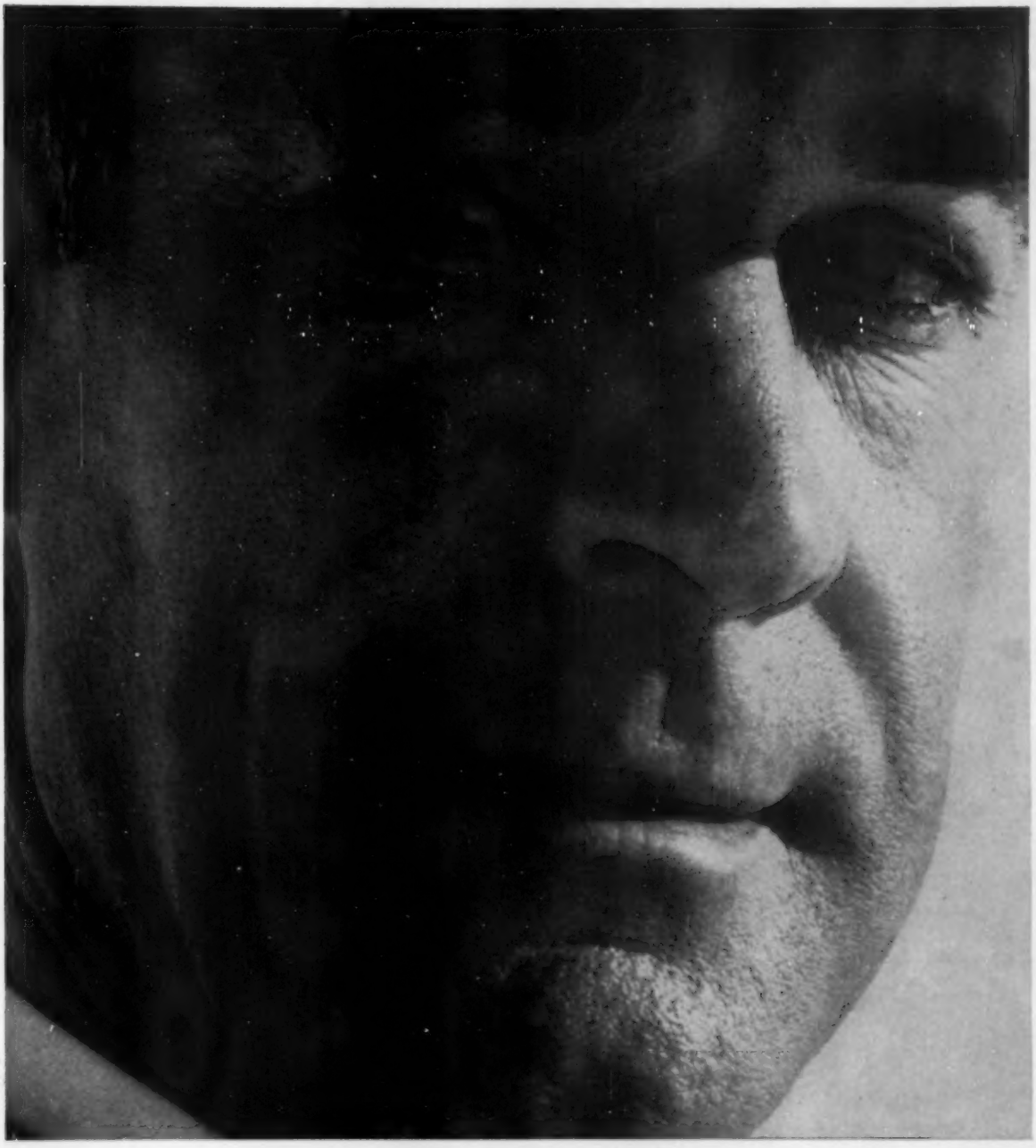


This Hewitt-Robins slope conveyor takes ore from a 48" H-R dock conveyor which runs the length of the Canton Railroad ore pier in Baltimore. It carries 3,000 tons of ore per hour up a 16° slope into a weighing station for loading into railroad cars.

This continuous flow of materials cuts handling costs, speeds turn-around time for ships and shore carriers. Here, as in hundreds of industrial applications, Hewitt-Robins engineered, manufactured, and installed the complete bulk materials handling system. To find out how H-R products and services can help you, consult your classified telephone directory for the nearest H-R representative, or contact Hewitt-Robins, Stamford, Connecticut.

HR HEWITT-ROBINS

CONVEYOR BELTING AND IDLERS . . . POWER TRANSMISSION DRIVES
INDUSTRIAL HOSE . . . VIBRATING CONVEYORS, SCREENS & SHAKEOUTS

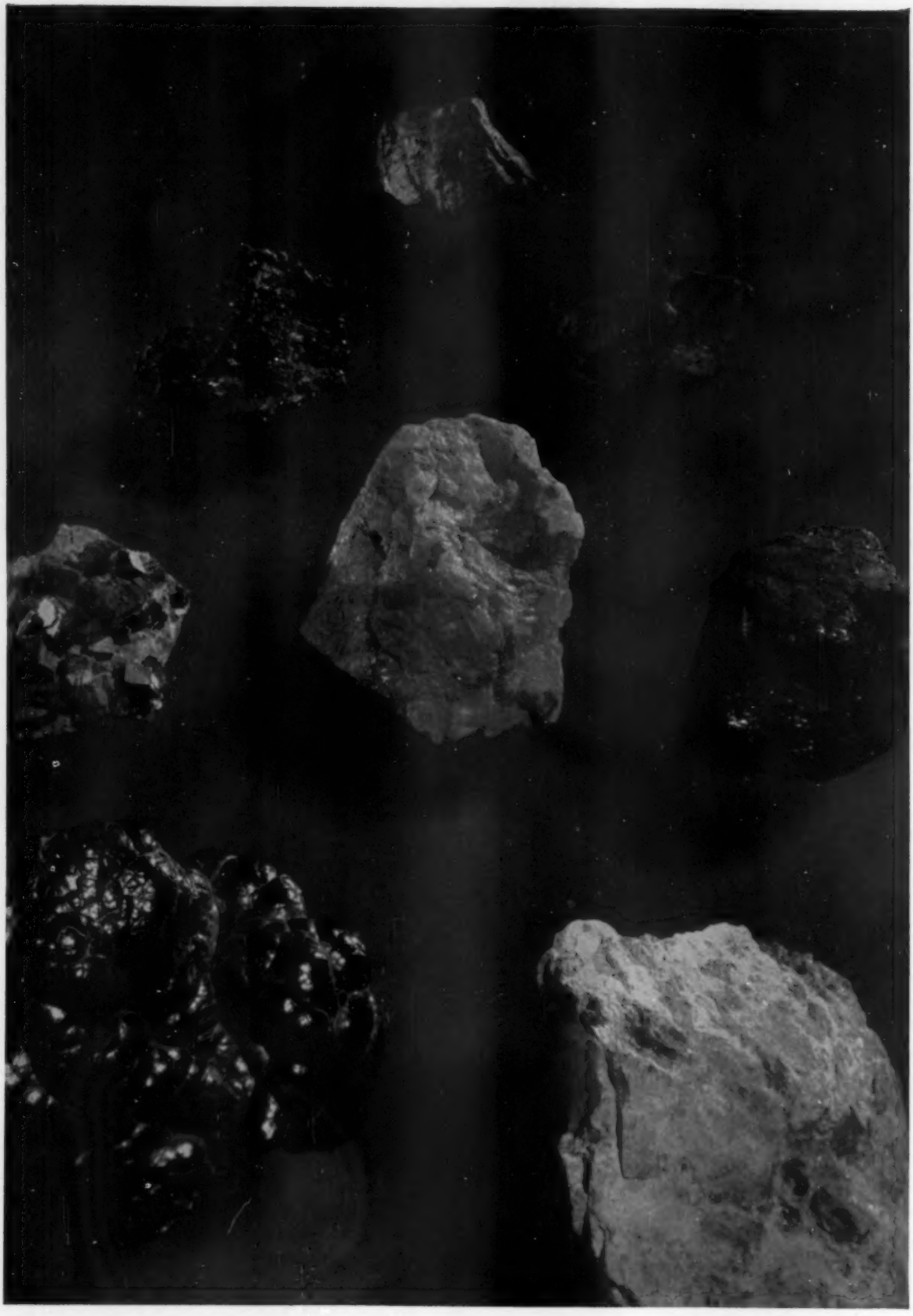


When your process calls for chemicals talk to the man from Dow

YOU CAN DEPEND ON DOW FOR: XANTHATES • DOWFROTH® 250 • Z®-200 • SEPARAN 2610® • HYDROCHLORIC ACID • AMMONIA • CHLORINE
CAUSTIC SODA • VERSENE® • MAGNESIUM OXIDE • MAGNESIUM HYDROXIDE • ION EXCHANGE RESINS • SOLVENT EXTRACTANTS

THE DOW CHEMICAL COMPANY • MIDLAND, MICHIGAN

DOW



These represent a few of the minerals with which Separan 2610 is improving flocculation and lowering processing costs: CHROMITE, URANINITE, GALENA, SPHALARITE, CHALCOCITE, ALUMITE, COAL, HEMATITE.

For a wide variety of minerals Separan 2610 provides record-speed flocculation

NEW FLOCCULANT PROVES ITSELF IN NUMEROUS OPERATIONS

It's a fact—proven in many types of operations, with a wide variety of materials: Separan 2610® has doubled, and often tripled, production rates!

Equally remarkable: only a few hundredths of a pound are needed per ton of solids!

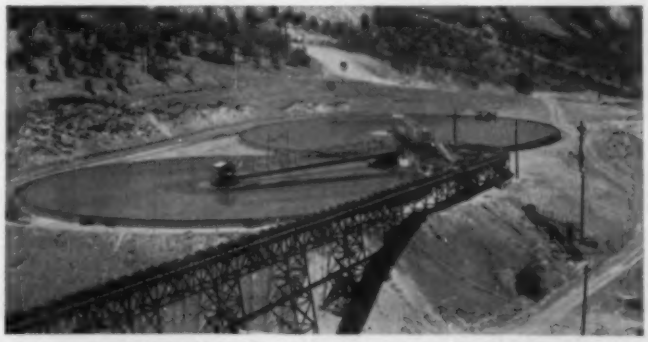
New economies are being realized in processing uranium, lead, and zinc, coal, copper, alum, and a host of other sulfide and non-sulfide minerals. Operations involving concentration, leaching, thickening, and refining are benefiting with Separan 2610, especially since this revolutionary flocculant is so easy to prepare and apply. A mechanical mixer is not required. You can prepare large amounts of stock solution with a new dispenser recently made available. And Separan 2610 is effective in both acid and alkaline circuits. In addition, it adds no excess bulk.

Try Separan 2610 yourself!

Available from three f.o.b. points: Midland, Michigan; Pittsburg, California; and Velasco, Texas . . . and from two stock points: Port Newark, New Jersey, and St. Louis, Missouri. A sample and technical assistance are yours upon request. THE DOW CHEMICAL COMPANY, Technical Service and Development, Midland, Michigan, Dept. SE1315B.

When your process calls for chemicals, talk to the man from Dow

XANTHATES • DOWFROTH® 250 • Z®-200
SEPARAN 2610 • HYDROCHLORIC ACID
AMMONIA • CHLORINE • CAUSTIC SODA
VERSENE® • MAGNESIUM OXIDE
MAGNESIUM HYDROXIDE • ION EXCHANGE
RESINS AND SOLVENT EXTRACTANTS.



HERE ARE EXAMPLES of how little Separan 2610 is required: In thickening copper tailings, clearer overheads and better filtration are reported with only 0.0041 pounds per ton of solids. Similar improvements are taking place in uranium filtration at 0.5 pounds per ton.

YOU CAN DEPEND ON DOW

"THIS D9 HAS DONE EVERYTHING WE HAVE TRIED IT ON YET!"

V. D. Eachus, Eachus Equipment Rental Co., Las Vegas, Nevada

This CAT* D9 Tractor with No. 9S Bulldozer is stripping overburden from gypsum in the Blue Diamond Corporation's operation, Blue Diamond, Nevada. The material is clay and rock. Says V. D. Eachus, owner of the unit: "This D9 has done everything we have tried it on yet. It is a big tractor and it does a big job. I have owned Caterpillar-built machines now for about fifteen years and find they stand up best on the toughest of work. Our dealer service is also tops."

That's typical of other reports about the Turbocharged D9. In every way, it's a big machine for your biggest, toughest jobs. It packs plenty of power — 260 HP at the drawbar and 320 HP at the flywheel. Its turbocharger, driven by the engine exhaust, packs air into the engine according to engine load, not engine speed, for greater efficiency. With bulldozer it weighs 35 tons, yet is as easy to maneuver as smaller machines, with hydraulic boosters providing power for steering, braking and master clutch use. And it's easy to service — for example, oil clutch, torque converter, transmission and steering clutches each can be moved individually.

To match your job needs, the D9 is available with torque converter or direct drive with oil clutch. For complete information, see your Caterpillar Dealer, who's a source of efficient service and parts you can trust. Ask him to show you facts and figures proving the D9 can step up your production. Better still, name the date — he'll be glad to demonstrate!

Caterpillar Tractor Co., Peoria, Illinois, U. S. A.

CATERPILLAR*

*Caterpillar and Cat are Registered Trademarks of Caterpillar Tractor Co.

WANTED— THE HARD WORK

Manufacturers News

News
Equipment
Catalogs

• FILL OUT THE CARD FOR MORE INFORMATION •

Belt Splice Protection

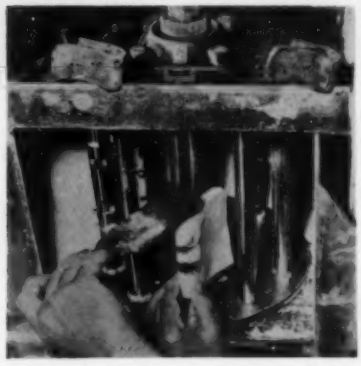
A new self-vulcanizing rubber repair material, REMA, will cover belt splices made with Flexco fasteners by *Flexible Steel Lacing Co.* REMA is claimed to prevent seepage of fines, seal out moisture, reduce mildew and rot. Belt can be put into operation immediately after application. **Circle No. 1.**

Sump Pumps

Two new self-priming air-powered sump pumps are announced by *Atlas Copco AB.* Capacities range from 222 gpm at a 30-ft head to 20 gpm at a 200-ft head. Operating pressure is 85 psi for both 50-lb pumps and they will operate when wholly submerged and start under full load. In each, a vane type motor and an impeller type centrifugal pump are contained in one-piece housings. **Circle No. 2.**

Iron Fines Removal

Accidental iron fines can be separated from material such as finished zinc oxide by using a permanent magnetic Roto-Grate by *Eriez Mfg. Co.* Powered with magnetic



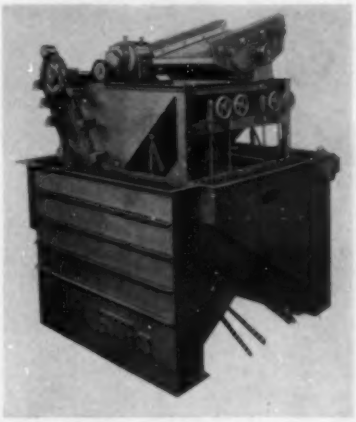
tubes of Alnico V, the nonelectric grate revolves slowly through the passing flow of material, preventing clogging or bridging, breaking up particles that cling together, and drawing out stray iron fines that become firmly secured to the magnet tubes. **Circle No. 3.**

Skid-Shovel

Versatility is the keynote for *International Harvester's* Drott "Four-in-One" Skid-Shovels. Newest available is the 3-yd 134-hp TD-18. This rig, operated hydraulically, can be converted instantly from skid-shovel, to bullclam, to clamshell, or to bulldozer by flicking a lever located within easy reach of the operator. Hydro-Spring feature eases operating shocks and cuts down on hydraulic line failures. **Circle No. 4.**

Wet Jig

An improved steel jig for processing iron ore, manganese ore, slags containing reclaimable metal, and similar materials has been introduced by *McLanahan & Stone Corp.* Self-contained two-cell unit screens feed and passes it into a divided hopper. As plungers go down in jig cylinders, water under pressure lifts material on the jig beds to resettle it with the heavier ore on bottom. Continual pulsating separates ore from waste. All working parts are visible. **Circle No. 5.**



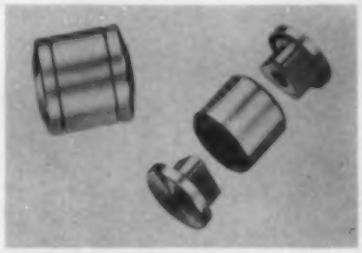
Portable Generators

Thor Power Tool Co. enters the portable electric generator field with two 1500-w models featuring vertical shaft design. Gasoline-powered, the a-c model, EG-1.5A or the d-c model, EG-1.5D will generate 115 v at 13

amp. A pipe framework provides a simple shock mount and also serves as protective guard and carrying handle. The compact 23-in. diam units weigh 95 lb each, are 23¾ in. high. Two plug-in outlets are provided. **Circle No. 6.**

Flexible Couplings

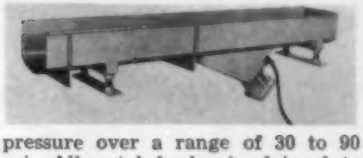
Flex-Ring couplings by *Smith & Serrell Inc.* consist of two aluminum hubs that fit into synthetic rubber molded into an aluminum center ring. No lubrication is needed and



backlash is no problem. Three new couplings offer bore sizes ranging from 3/16 to 1¼ in., diameters from ⅞ to 2½ in., and lengths from ⅞ to 2¼ in. Designed for fractional horsepower duty, the couplings are easily installed and aligned. **Circle No. 7.**

Vibrating Feeder

A pneumatic drive mechanism generates vibrating force in a new feeder for such bulk material as sand and gravel. *Cleveland Vibrator Co.* offers the unit in pan, trough, or tubular construction. Frequency of vibration, which controls feedrate, is selected by varying operating air



pressure over a range of 30 to 90 psi. All-metal feeder is claimed to operate under adverse conditions of corrosion and high temperature. **Circle No. 8.**

News & Notes

A one-piece conveyor belt by *B. F. Goodrich,* 60 in. wide and more than 1000 ft long, will carry iron ore for Orinoco Mining Co. at Puerto Ordaz, Venezuela. . . . *R. G. LeTourneau Inc.* has announced plans to re-enter the earthmoving field in 1958 after a

five-year absence. A new trade mark (shown) has been designed for heavy equipment. . . . *Thor Power Tool Co.* is transferring its executive offices from Aurora, Ill., to the Prudential Building in Chicago.

Steep Rock Lake . . .

another example of how Bucyrus-Erie rotaries cut blast hole drilling costs

At Steep Rock Lake, 140 miles west of Port Arthur in Ontario's Rainy River district, Steep Rock Mines Ltd. recently replaced three cable tool drills with one Bucyrus-Erie 40-R rotary blast hole drill. Working in the dewatered Hogarth open pit section of the lake's basin, the electric-powered 40-R drills 7⅞-in. holes in high grade direct-shipping ore with an average iron content of 60%.

The cable tool drills were delivering 50 feet of 9-in. hole per 8-hr. shift. Average hole depth was 28 feet. Cost records for early stages of 40-R operation show that the machine has cut drilling costs per foot of hole (average hole depth is the same) by more than 50%.

This is just one of many case histories which are proving the drilling superiority of Bucyrus-Erie rotaries daily. Behind performance like this are these outstanding features: rotary drive with Ward Leonard control of rotating speed; hydraulically powered pulldown force; remote-controlled power-driven tool handling unit; and air-blast cleaning of drill holes.

For complete information on the 40-R, write today. Also ask about the larger 50-R machine for drilling 9⅞ to 12¼-in. holes.

35856C-e

BUCYRUS-ERIE COMPANY

SOUTH MILWAUKEE, WISCONSIN

(21) HANDLING & PROCESSING: Brief descriptions of the *Jeffrey Mfg. Co.* line of material handling and processing equipment are given in 44-page Catalog 860-A. Among the many items listed are conveyors, vibrating screens, crushers, dryers, magnetic separators, bin level indicators, fans and blowers. A useful table is included on average densities of typical solid materials as they occur in material handling and processing operations.

(22) INDUSTRIAL LOCOMOTIVES: Case histories of various *General Electric* industrial locomotives are contained in a new 24-page booklet. Operating conditions and performances of 14 switcher-type and mining locomotives are outlined. The GE line varies in size from 1½ to 50 tons; and battery, trolley, trolley cable reel, and diesel-electric mine locomotives are offered.

(23) ARC WELDERS: Arc welding machines and accessories are catalogued in a new brochure from *Air Reduction Sales Co.* Airco units listed include selenium rectifier and d-c motor generator welders, a-c and d-c engine driven welders, and a-c transformer welders. Specifications are included for each, from ampere ratings to dimensions.

(24) PROCESS CONTROL: *Fischer & Porter Co.* has a new 32-page catalog describing a line of products for process instrumentation. New bulletin, which includes prices, covers indicating, recording, controlling, and transmitting instruments for flow, pressure, and density.

(25) ROLLER CHAIN: LXS bushed roller chain for long life under severe conveyor and drive conditions is described in Book 2454 from *Link-Belt Co.* Straight and offset sidebar types are supplied with small or large rollers to cover a variety of power transmission or conveyor applications. Both types operate on standard wheels, and attachments are available.

Free Literature

(26) BELT CONVEYOR IDLERS: Idler selection charts speed reader selection of proper belt conveyor idlers for specific service requirements in Bulletin 56-80 from *Chain Belt Co.* Belts are "Rex-Rated" according to material handled, operating conditions, and life expectancy into four major classes. Series 1000 are intended for moderate service, Series

2000 for standard service, Series 3000 for heavy service, and Series 4000 for super service.

(27) MAGNETIC SEPARATORS: Design and application of high intensity induced roll magnetic separators is discussed in technical bulletin MIB-103 by *Carpco Mfg. Inc.* Machines are engineered to provide clean separation at high feed rates. Covered are operating characteristics, power requirements, and shipping specifications of both technical and industrial models.

(28) MICROFILMS: The widening scope of microfilm as an everyday office, engineering department, and record room work tool for active paperwork is detailed in a new 36-page brochure from the Filmsort Div., *Dexter Folder Co.* Booklet describes the Filmsort system for making microfilm more useful by mounting it in aperture cards or jackets; gives details of new equipment, supplies and techniques for handling engineering drawings, personnel and other office records; and provides case histories on applications, savings, and other benefits.

(29) DUMP TRUCK HOISTS: A new 4-page catalog from *Galion Allsteel Body Co.* describes Uni-scopic single front mounted and Duo-scopic twin front mounted telescopic hoists. Specifications cover nine models with capacities from 9 to 34 tons. Matching bodies and accessories are also described in Catalog LL-4094.

(30) METALLURGICAL SERVICES: The *Galigher Co.* offers a brief pamphlet on the design and engineering services of their metallurgical division.

(31) DUST & FUME CONTROL: Bulletin G406 from *Western Precipitation Corp.* describes and illustrates a line of dust and fume control units. Among the equipment, intended for collection of suspended materials from gases and liquids, are Cottrell electrical precipitators, Multiclone dust collectors, Holo-Flite indirect heat exchanger processors, Dualaire reverse jet dust collector, and spray and dispersion dryers.

(32) CONCRETE DENSIFIER: Sikacrete accelerating densifier for concrete and mortar is described in Folder SI-56 from *Sika Chemical Corp.* The aqueous solution controls cement-gel formation to reduce shrinkage, and increase workability, density, uniformity, strength. It is claimed to accelerate cold-weather setting and produce high early strength.

MAIL THIS CARD

for more information on items described in Manufacturers News and for bulletins and catalogs listed in the Free Literature section.

4

Mining Engineering **29 West 39th St.** **New York 18, N. Y.**

Not good after July 15, 1957—if mailed in U. S. or Canada

Please send { More Information ☐ / Price Data ☐ / Free Literature ☐ } on items circled.

Name_____ Title_____

Company_____

Street_____

City and Zone_____ State_____

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64						

Students should write direct to manufacturer.

(33) WEATHER-PROTECTED MOTOR: A new weather-protected motor for non-hazardous outdoor installations is offered by *Allis-Chalmers Mfg. Co.* Available in ratings of 250 hp and larger, the new motor is built into a rigidly constructed steel frame equipped with two removable air ducts. Immersion type space heaters for inactive periods are standard equipment.

(34) WELDING CHART: *Hobart Bros. Co.* has a wall chart with details on proper welding procedure, hints for correcting common troubles, and instructions for use of various Hobart electrodes.

(35) MAGNESIUM & TITANIUM: A new 44-page booklet of magnesium and titanium data covers information needed for design work. Included are physical and mechanical properties, forming characteristics, corrosion behavior, surface treatments, welding and joining, machining, heat treatment, and stress relief. *Brooks & Perkins Inc.* offers the information.

(36) DIAMOND DRILLING: *Joy Mfg. Co.'s* Bulletin D-38, "Do's and Don'ts for Diamond Drilling," sets forth basic techniques in simple terms. Operating tips are included with recommendations for various formations, and general information.

(37) PRESSURE CENTRIFUGE: Details on the first commercial centrifuge for high pressure operation are given in Bulletin 2600 from *Dorr-Oliver Inc.* The Merco centrifuge is designed for continuous centrifugation at pressures as high as 110 psi. Two sizes are available—the PC-30 model with capacity of 40 to 250 gpm, and the laboratory scale PC-9 model with capacity of 1 to 20 gpm.

(38) TOOLS & METHODS: A newly revised booklet, "Carmet Mining Tool Catalog & Methods Manual" is offered by the Carmet Div., *Allegheny Ludlum Steel Corp.* The 16-page manual gives details and illustrations on a variety of mining bits.

(39) MOTOR SCRAPER: Design, engineering, construction, and operating features of the *Allis-Chalmers* TS-360, 20 cu yd motor scraper are described in new 16-page catalog MS-1104.

(40) ASARCO REVIEW: A 28-page, four-color pictorial review of the mining, smelting, refining, and research operations of *American Smelting & Refining Co.* has been released.

(41) PETRO-ENGINEERING: A cost-free service providing practical assistance on problems involving fuels, lubricants, and other petroleum products is offered by *Gulf Oil Corp.* Maximum fuel economy, reduction of number of lubricants used, more efficient storage, reduction of maintenance costs are some of the advantages claimed. A 24-page booklet on the petro-engineering service supplies full details.

(42) DRILLING & BLASTING: A new brochure from the Explosives Dept. of *American Cyanamid Co.* outlines current information on drilling, blasting, and excavating methods. "Construction Case Histories" includes a 3-page chart presenting 48 case studies. Information is included on geological formations, excavating practices, drilling equipment, bit performance, drill patterns, blasting data, and explosives ratios. Also included are plan views of blasting patterns.

(43) EXPLOSIVES PRODUCTS: A complete catalog-manual from *Olin Mathieson Chemical Corp.* details products of the company's Explosives Div. The 80-page booklet, C-15, gives references on dynamite, black powder, blasting caps, electric and delay electric blasting caps, seismograph caps, and other blasting supplies. A rear section guide of useful information gives standard cartridge counts for a given powder weight, average resistance of electric caps, field use calculations, handling and storage data, and safety rules.

(44) FINE SCREENING: *Nordberg Mfg. Co.'s* Symons V screen multiplies screening action by combining centrifugal and gravitational forces for sizing, dewatering, dedusting, cleaning, and washing. Controlled diffused feed and vertical flow of material are used with low rotary speed and high speed gyratory action. Screen has been used for metallic ores, coal, sand, gravel, phosphate rock, limestone, perlite, mica, pumice, asbestos, among others.

(45) HORIZONTAL PRESSURE FILTERS: *Cochrane Corp.* Publication 6322 furnishes details on type D horizontal pressure filters. Described are filter bed materials, design features, operation, control, and accessories. Drawings illustrate various arrangements of two, three, and four header units.

(46) VALVES: Circular 555 from *Lunkenheimer Co.* is a "Guide for Selecting Valves, Boiler Mountings, Lubricating Devices." Twenty-four pages of tables and technical data give information on the entire line of valves.

(47) DIRECT MOUNTING MOTOR: A new totally-enclosed motor with facilities for direct mounting to the equipment to be driven is offered by *U. S. Electrical Motors Inc.* Accurate alignment is provided by a totally-enclosed NEMA style C bracket with tapped holes. Motor is available in ratings of 1 to 30 hp.

(48) STOPPING LEAKS: Quick setting mortar for stopping leaks is said possible with Quickset chemicals from *Sika Chemical Corp.* The liquids are available in two types for high and moderate pressure leakage. Sika No. 2 will cause mortar to set in 15-30 sec, and No. 4A in 45-60 sec.

(49) ENGINEERING SECRETARIES: A pamphlet explaining the aims of the engineering secretarial course offered by *Business Training College* is available. Students of the school complete secretarial studies which stress engineering terminology. Graduates will seek the opportunity to become assistants as well as secretaries to engineers.

(50) LAB COAL CRUSHERS: *American Pulverizer Co.* offers a new bulletin describing laboratory crushers for preparing coal samples needed in buying and selling coal according to specified requirements. Capacities range 600 to 2000 lb per hr. Shown are several types of sampling discharge hoppers and rifle splitters.

(51) LUBRICATION FITTING: Keystone RT fittings are claimed to cut lubrication time and prevent overlubrication of ball and roller bearings. Bulletin BU-61 from *Keystone Lubricating Co.* gives details on the relief-type fitting which may be attached to conventionally-equipped units.

FIRST CLASS
PERMIT No. 6433
Sec. 34.9 P.L.&R.
New York, N. Y.

BUSINESS REPLY CARD
NO POSTAGE STAMP NECESSARY IF MAILED IN THE UNITED STATES

3c.—POSTAGE WILL BE PAID BY—

MINING ENGINEERING

29 WEST 39th STREET

NEW YORK 18, N. Y.

105 Tractor—Excavator powered by 143 HP GMC Diesel engine can lift and load single pieces up to 12 tons.

THE EIMCO 105 EXCAVATOR LOADS MORE - FASTER .. CHEAPER

Eimco 105 Tractor-Excavators operate on a 10 to 12 second loading cycle. This speed can be maintained under ideal conditions.

Greater Capacity at 1/3 Initial Cost -

In tough conditions the 105 will out-perform other excavating equipment on a more impressive scale. It will pick up and discharge into the haulage unit much larger pieces of material than will go thru the bottom of a bucket on a boom shovel of equal (1½yd.) capacity.

The 105 will exert greater digging force at the bucket lip than the larger, more expensive boom equipment - often eliminating blasting.

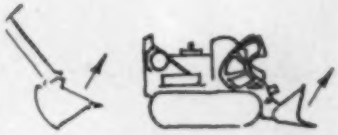
Equipment used around boom shovels such as bulldozers (for pushing up the broken rock) are eliminated with the Eimco 105 because this maneuverable tractor mounted excavator does its own bulldozing.

Eimco 105's are rugged, heavy duty machines, built to stay working on the job. Proven overall operating and maintenance costs are 40% less than boom shovels of same bucket capacity. Independent final drives provide greater maneuverability. Up-front position for the operator gives him full visibility. There are many other advantages in the 105. Write for complete information.

COMPARE

BOOM SHOVEL—EIMCO

11/2 yard boom bucket loading is limited to size that will go thru bucket. Eimco 11/2 yard bucket load is limited only to weight machine can lift.



COMPARE

BOOM SHOVEL—EIMCO

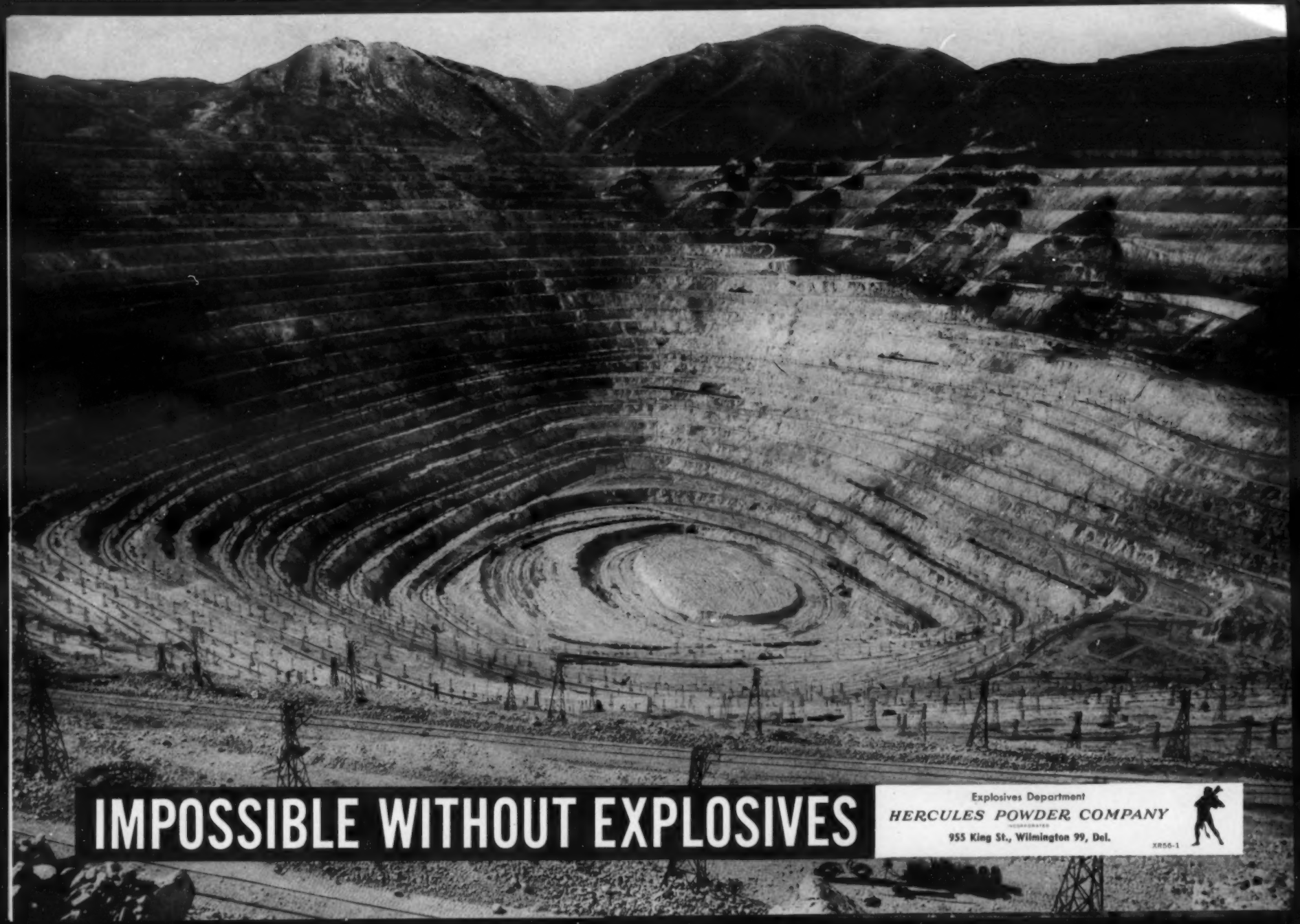
Digging effort on 11/2 yard boom shovel (45° boom angle bucket on ground) 24,000#. Digging effort on 11/2 yard Eimco shovel 39,200#.

THE EIMCO CORPORATION

Salt Lake City, Utah—U.S.A. • Export Offices: Eimco Bldg., 52 South St., New York City

New York, N. Y. Chicago, Ill. San Francisco, Calif. El Paso, Tex. Birmingham, Ala. Duluth, Minn. Kellogg, Ida. Pittsburgh, Pa. Seattle, Wash.
Cleveland, Ohio Houston, Tex. London, England Gateshead, England Paris, France Milan, Italy Johannesburg, South Africa

B-345


IMPOSSIBLE WITHOUT EXPLOSIVES
Explosives Department
HERCULES POWDER COMPANY
INCORPORATED
955 King St., Wilmington 99, Del.
XR56-1

At A Sand Tunneling Project

AN EIMCO 630 DISPLAYS SPEED, POWER, VERSATILITY

Contracting firms at a large West Coast storm drain project employ a unique sand tunneling method that utilizes the loading speed and versatility of an Eimco 630 Crawler-Excavator.

The Eimco mucks at the base of a shield forced into the tunnel face by hydraulic rams bearing against the last set. The shield's broad apron sustains the ceiling and sides of the new cut until supports are installed.

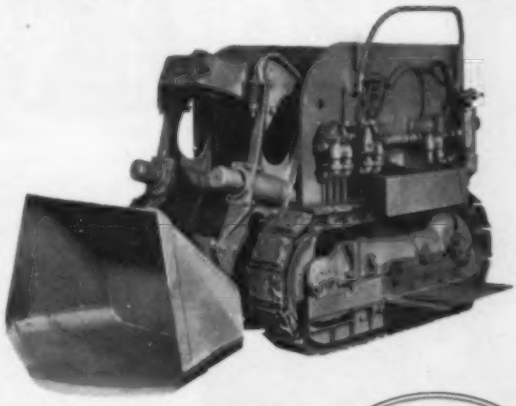
Here are some of the operating advantages being displayed by the Eimco 630:

1) **Loading Power . . .** Though procedure does not require blasting, material at the face is tightly packed. The Eimco's 6,000 pound digging power and independent track maneuverability (it crowds from any angle without making a new approach) are used advantageously to force the half-yard bucket into the face.

2) **Discharge Speed and Versatility . . .** The 630 reverses about 35 feet to discharge into a large hopper on side-mounted rails. To load in the cramped (10' rounded horseshoe) sections, the Eimco relies on overhead rocker arm discharge. While the machine moves from the face to the hopper, the operator gets the loaded bucket into dumping position . . . thus lost motion between excavating and discharge is held to a minimum. The Eimco traverses the 70 foot cycle and still dumps two cubic yards into the hopper every minute . . . enough to load a six (4 cu. yd.) car train every 14 minutes. Daily progress averages 35 feet.

3) **Dependable Service . . .** The Eimco is giving dependable on-the-job service while working in this abrasive sand . . . a real test of the machine's rugged and protective construction features.

The Eimco 630 is constantly meeting new challenges and getting greater tonnages at low operating costs. Watch it in action . . . then you be the judge!

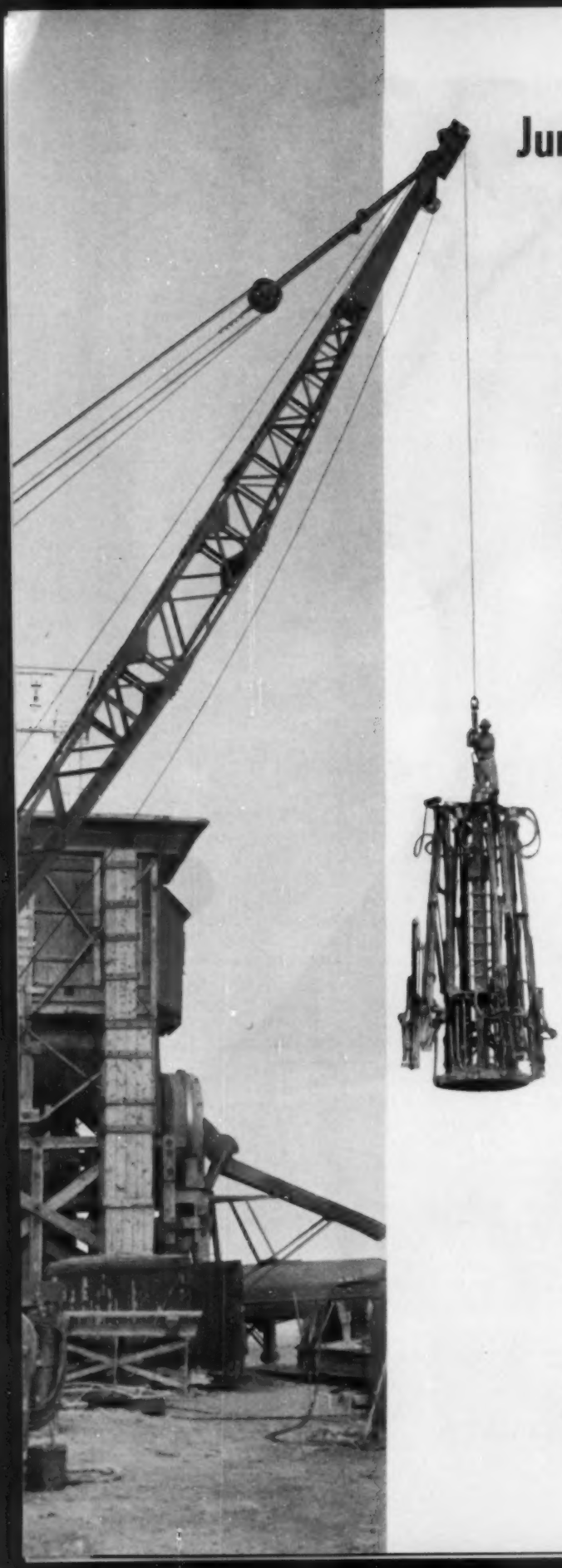


THE EIMCO CORPORATION

Salt Lake City, Utah—U.S.A. • Export Offices: Eimco Bldg., 52 South St., New York City

New York, N. Y. Chicago, Ill. San Francisco, Calif. El Paso, Tex. Birmingham, Ala. Duluth, Minn. Kellogg, Ida. Pittsburgh, Pa. Seattle, Wash.
Cleveland, Ohio Houston, Tex. London, England Gateshead, England Paris, France Milan, Italy Johannesburg, South Africa

B-947



Jumbo Sinks 18 Foot Diameter Shaft 10 Feet per Day!

Le Roi multiple drill rig speeds Wyoming mine project

"Only this Le Roi jumbo rig could make this kind of progress." That's the opinion of experienced mining engineers at the site of a new mine shaft near Green River, Wyoming.

Their job was to drive an 18 foot diameter ventilating shaft 1600 feet straight down through hard Wyoming rock. They did it in record time with a Le Roi Shaft Jumbo.

Le Roi's Shaft Jumbo is a self-leveling multiple drill rig. It has four extendible arms, each mounting a heavy sinker drill on an independently controlled 2-to-1 air-feed shell. Each arm is mechanically positioned by air motors.

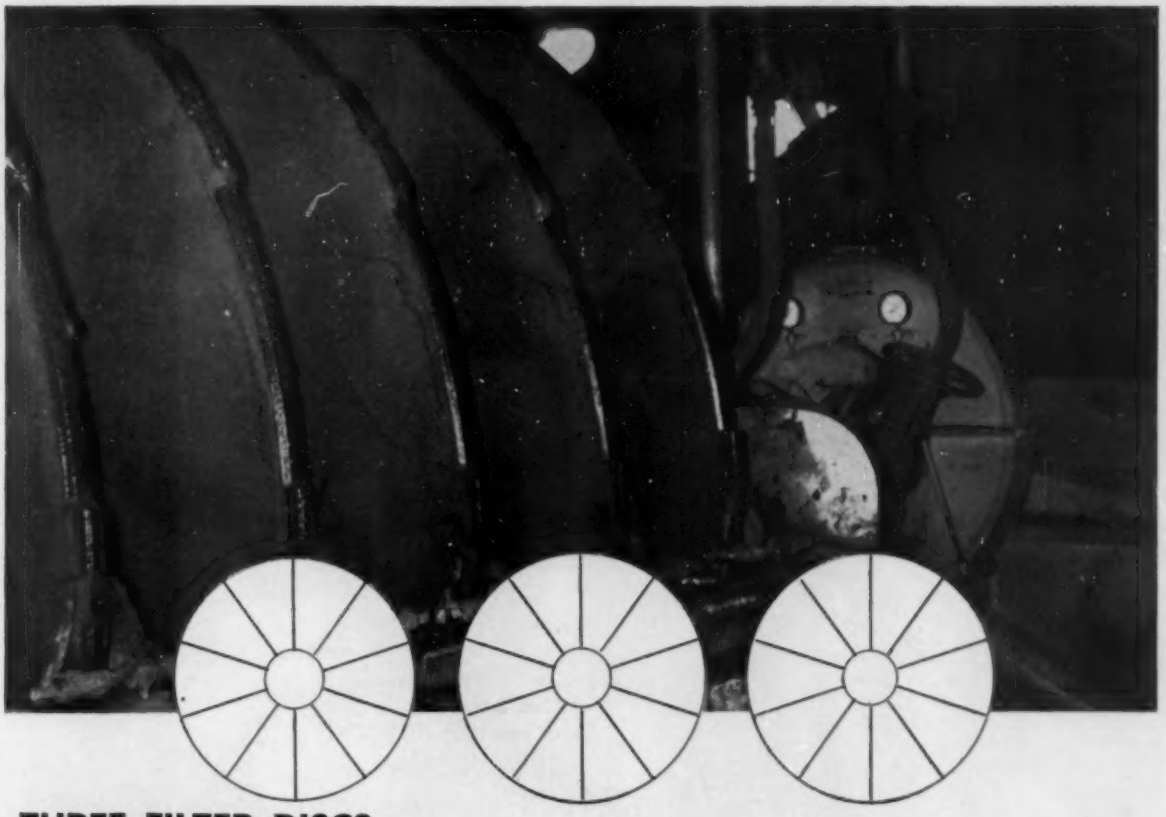
On the Wyoming job, each round in the hard formations required 65 holes drilled to an average depth of 12 feet. The drilling pattern included a row of holes spotted around the perimeter, with successive inner circles offset for maximum shattering and fragmentation.

Each complete drilling sequence was finished by the Jumbo in an average of 3 hours. By using the feed shells, instead of hand-held jackhammers, steel changing was eliminated. On a 65-hole round, 12 feet deep, time saved was considerable . . . and multiplied by the shaft depth, amounted to real money!

In addition, drilling was much more accurate using the positive feed, air-motor positioned drills. This meant more accurate patterns. Worker efficiency increased, too. Easily controlled feeding eliminated the big source of worker fatigue.

The Le Roi Shaft Jumbo can drill shafts from a minimum diameter of 11'-9" up to a maximum diameter of 28'-0", and shafts have been sunk with the Jumbo to a depth of 3,000 feet. Normally equipped with 4 drills, the Jumbo can be furnished with 2 or 6, if desired. It is also available with dust collectors. For complete information, contact your local Le Roi distributor, or write us direct.

LE ROI Division of Westinghouse Air Brake Co., Milwaukee 1, Wisconsin, manufacturers of Cleveland air tools, Tractair, portable and stationary air compressors, and heavy-duty industrial engines. Write us for information on any of these products.

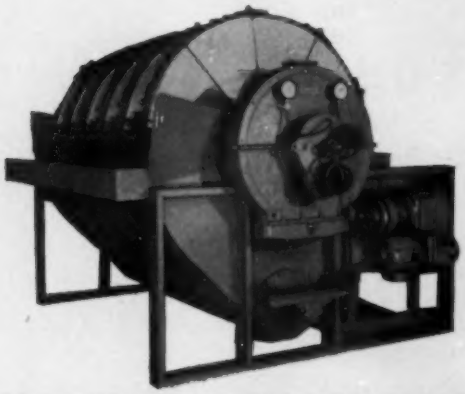


THREE FILTER DISCS . . .

They LOOK the same – TRUE!

Yes . . . to the unobserving eye these three illustrations of widely-used filter discs appear identical. But—in operation—there's a sharp contrast in their filtering capacities.

From left to right—Disc one is 8' 6" in diameter with **94** square feet of filter area . . . Disc two is 8' 10" in diameter with **104** square feet of filter area . . . Disc three is an 8' 10" diameter **EIMCO** disc with **110** square feet of filter area.



They ARE the same – FALSE!

Eimco's close attention to detail and superior engineering in disc design, get you more square feet of filter area per dollar of capital investment than any competitive make.

For example—Flow rate requirements of a processing firm called for 650 square feet of disc filter area. Eimco met production level requirements with a **six** disc filter while others were forced to specify a **seven** disc filter. **Since the price for each disc is essentially the same, Eimco saved this firm the cost of one disc.**

Further profit per unit of investment is being realized by this firm through Eimco's construction and design features that promote high filtration rates . . . minimum cake moisture content . . . low maintenance, filter media and operating costs . . . simplicity of operation and equipment durability.

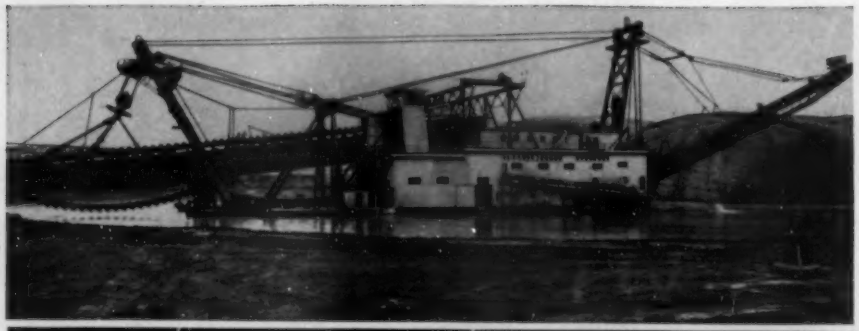
Why pay more when you can meet production needs with the BEST for LESS? Ask Eimco . . . in one way—or another—it will be a profitable contact for you, too!

THE EIMCO CORPORATION

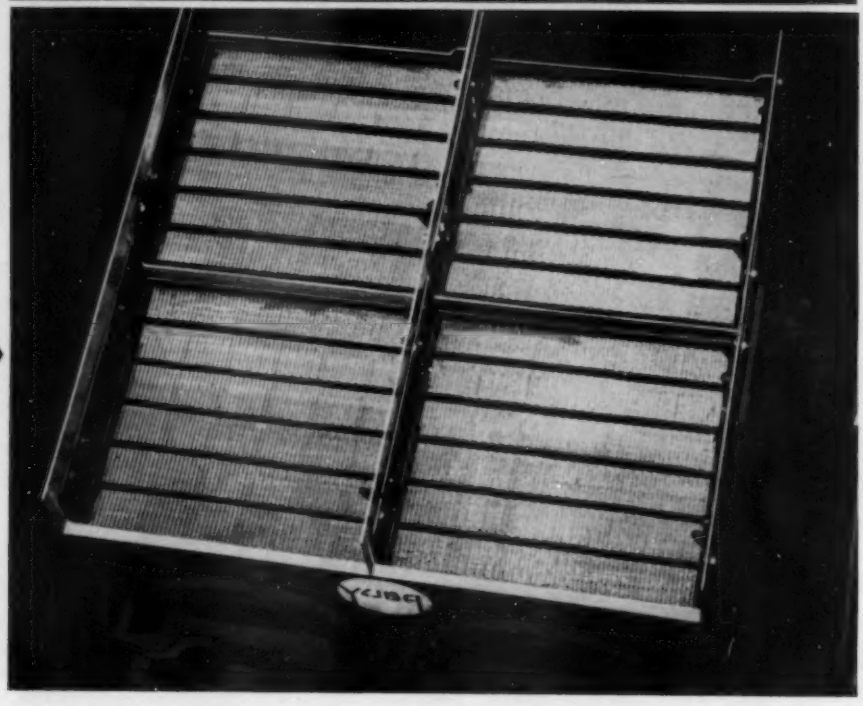
SALT LAKE CITY, UTAH

Research and Development Division, Palatine, Illinois • Process Engineers Inc. Division, San Mateo, California
Export Offices: Eimco Building, 51-52 South Street, New York 5, N. Y.
BRANCHES AND DEALERS IN PRINCIPAL CITIES THROUGHOUT THE WORLD

3-949



YUBA Gold Dredge floats on self-dug, land-locked ponds. 4 of these dredges can move about 13,000 cubic yards of placer material a day. Pay dirt is separated from waste through stainless jig screens.



Type 316 Stainless Steel Jig Screens solve abrasion and corrosion problem in Yuba gold dredging operation. Even after 7 years, screen stays open, resists rust, wear, clog-up. Mineral Jig built by Yuba Manufacturing Co., Hammonton, California.

Stainless steel screens going great shakes for YUBA

Last seven years and more. No rust. No clog-up.

Water . . . black sand . . . gold-bearing gravel . . . they're all in the day's shake of mineral jigs like this.

Yet Yuba Manufacturing Co. hasn't replaced its stainless steel screens in the last seven years. What's more, they're *still* in good condition.

"Just never wears out", says H. A. Sawin, Asst. Director of Sales, speaking of the austenitic chromium-nickel steel wire used.

Think of what that means in replacement costs . . . in downtime saved when Yuba operates as many as 48 of these 4-screen assemblies on a single gold mining dredge!

Could be you'll make a strike with stainless in your ore processing equipment. It's light. It's strong. It effectively resists corrosion and abrasion. It pans out in performance.

You can choose from a wide variety of stainless steels to meet tough corrosion and abrasion problems. We will be happy to make a few suggestions on the right alloy for you. Just write.

INCO TRADE MARK **THE INTERNATIONAL NICKEL COMPANY, INC.** 67 Wall Street New York 5, N. Y.

San Manuel to Reach Capacity by Summer

By July full production at annual capacity of 70,000 tons will be attained by Magma Copper Co.'s San Manuel mine in Arizona. Goal, first slated for the end of 1956, was advanced because of underground problems and failure of certain electrical equipment. San Manuel produced 39,076 tons last year—65 pct of expected capacity.

Latrobe Valley Lignite Being Exploited

Australia's 800-ft wide lignite bed in the Latrobe River valley, with proved reserves amounting to more than 20 billion tons, is undergoing removal of clay overburden. A lignite gasification plant at Morwell is now piping 3 million cu ft of gas to Melbourne daily. Experiments in converting the brown coal into highgrade metallurgical coke, already a laboratory success, are being tried in a small plant. Industrial prospects of the area will soar if this is accomplished because of a 100-mile-distant deposit of highgrade iron ore at Nowa Nowa.

Sulfur Output Started in Veracruz

Production of sulfur from the Isthmus of Tehuantepec in Southern Mexico has been started by the Mexican affiliate of Texas Gulf Sulphur Co., Compania Exploradora del Istmo. New output is the result of seven years of exploration and development, and investment of more than $10 million.

New Name in Titanium Production

Allied Chemical & Dye Corp. and Kennecott Copper Corp. have named their newly formed $40 million titanium company Allied-Kennecott Titanium Corp. A producing plant is expected in late 1958. The sodium reduction method will be used.

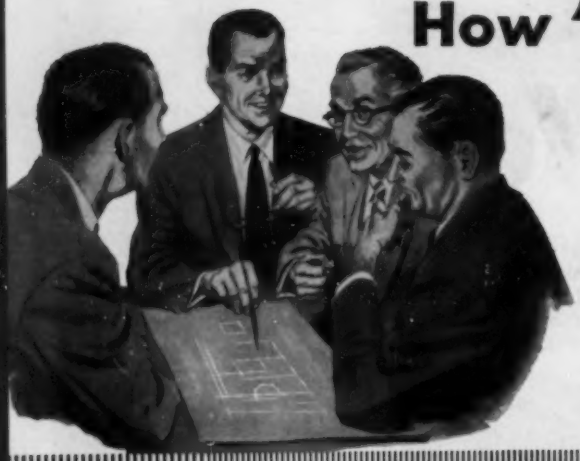
Form Bolivian Exploration Unit

Bolivex Corp., a new joint company formed by Vitro Minerals Corp. and Ventures Ltd. of Canada, intends to explore Bolivia's mineral potential. A program involving photogeological studies and aerial and ground surveys was presented to Bolivia last year. Completion of negotiations, expected this spring, will signal the start of field work.

Copper Drilling Along Lake Superior

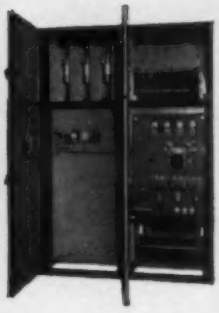
Test drilling along Lake Superior by at least one company is being done along a large area previously unexplored for submerged land mining. A bill now in the Michigan State Legislature would permit the Conservation Dept. to lease bottom lands for mining.

How "COORDINEERING" at ... Better



"Coordineering" may be defined as the integration of advanced thinking, planning and engineering that precedes the application of Allis-Chalmers equipment. With its staff, skill and experience, Allis-Chalmers is in a unique position to provide this valuable service.

Allis-Chalmers designs and builds all basic types



Crushing

An example of Allis-Chalmers "coordineering" is this crusher installation. Drawing on 75 years' experience in building and applying crushers, Allis-Chalmers control and crushing engineers developed a control circuit designed to cut costly downtime for the crusher installation shown above. In this circuit, motor overload protection is provided by *two* sets of thermal overload relays. One set operates at slight overload to sound warning. The second set stops the motor when temperature reaches the danger point.

Because of high starting torque and frequent starting under load, an Allis-Chalmers wound-rotor motor is used. In calculating horsepower requirements, the factors of crushability, ratio of reduction, product size and specific gravity are evaluated.

Flexibility in the Crusher

The crusher is the *Superior* gyratory crusher which features "one-man, one-minute" positioning of mainshaft and mantle. This control facilitates emptying crushing chamber in case of power failure or other emergencies. It also compensates for wear on concaves and mantle and, when required, changes product size instantly. In Allis-Chalmers gyratory crushers, changing eccentricity, speed, or shape of chamber varies capacity and product size. This flexibility permits synchronizing crushing with other operations.

Superior is an Allis-Chalmers trademark.

Hammermills

Vibrating Screens

Jaw and Gyratory Crushers

Grinding Mills

Kilns, Coolers, Dryers

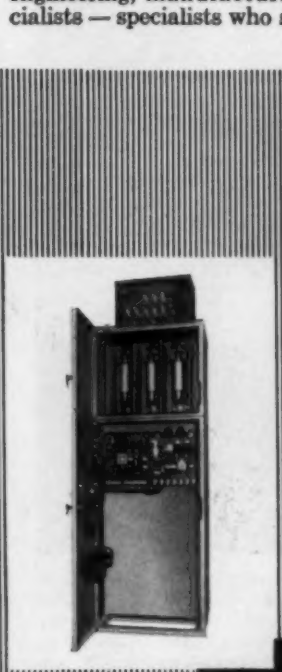
ALLIS-

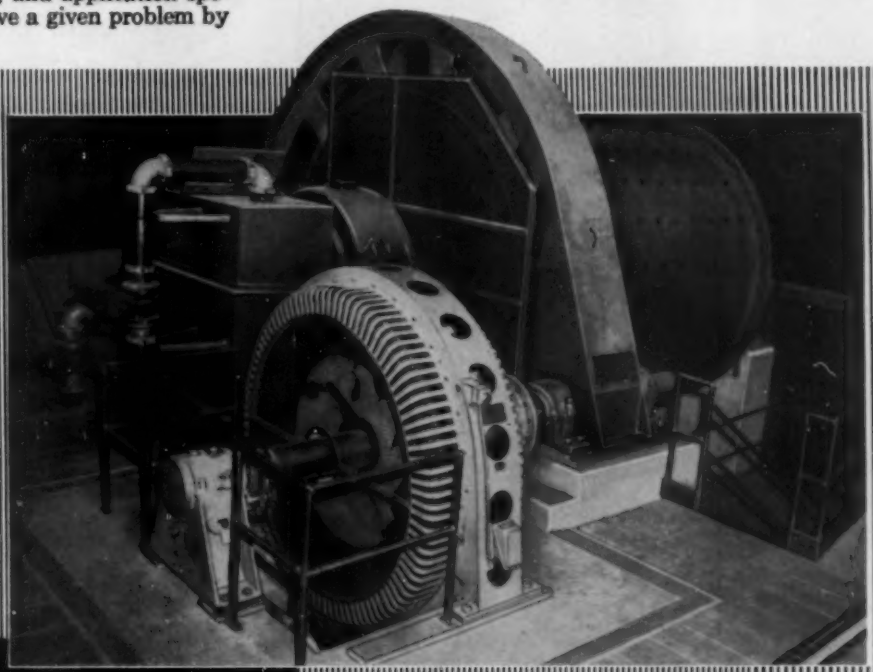
Allis-Chalmers Provides Better Methods

Results for You!

of processing machinery. In addition, the company manufactures complete lines of electrical generation, distribution and utilization equipment. As a result, Allis-Chalmers has a tremendous reservoir of experience—a most diversified team of research, engineering, manufacturing and application specialists — specialists who solve a given problem by exchanging ideas and correlating specific know-how and skills.

Only Allis-Chalmers can give you truly integrated equipment — because only Allis-Chalmers can give you "coordineering."





Grinding

In solving a grinding application, requirements and variables are given a careful going over by an Allis-Chalmers team comprised of *grinding, motor* and *control* engineers. Characteristics of material, capacity, feed preparation, balance of gradations, torque characteristics, system power factor needs, control requirements are some of the many factors evaluated. Experience has proved that this thorough pre-application investigation and preparation pays off to the purchaser . . . *pays off in providing a modern, efficient grinding circuit with the lowest operating cost.*

An Integrated Grinding Mill Installation

In a typical application, the mill installed was a 10½ by 12-foot Allis-Chalmers diaphragm ball mill. The close diameter-length ratio is an important factor in producing the highest possible capacity per unit of power. Driving the mill is a 900-hp, 4000-volt, 257-rpm, 0.8 pf Allis-Chalmers synchronous motor. By providing desired power factor correction, this motor reduces power cost. The Allis-Chalmers starter is specially engineered to provide protection under all conditions of grinding operation. A-4915

★ **You'll want Bulletin 25C6166D.** It covers all equipment manufactured by Allis-Chalmers for the mining industries. See your nearby A-C representative or write Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wisconsin.

CHALMERS

A-C ALLIS-CHALMERS

NOW... DRILL 9" HOLES WITH THE NEW

JOY HEAVYWEIGHT CHAMPION

This world-famous pioneer rotary-air-blast-drill has adopted many of the features of its big brother, the Super-Heavyweight, to give you these advantages:

MORE STABLE DRILL STRING through use of round pipe . . . BETTER AIR CIRCULATION and cuttings removal . . . FASTER DRILLING—faster retraction of hydraulic feed averages total of only 3 minutes on a 51′ hole . . . EXTENDED 55′ MAST permits drilling 50′ hole without adding pipe . . . BETTER MOBILITY —hydraulically raised and lowered mast is left assembled during long moves . . . 9″ HOLE allows wider hole spacing, economical use of large diameter powder.

This all adds up to new records in low cost per ton of rock. Get the whole story on the 58-BHR. Write to ***Joy Manufacturing Company, Oliver Building, Pittsburgh 22, Pa.*** In Canada: Joy Manufacturing Company (Canada) Limited, Galt, Ontario.

Write for Bulletin 168-7.

JOY... EQUIPMENT FOR MINING... QUARRYING... CONSTRUCTION

WBW M 6565-168

PORTABLE AND SEMI-PORTABLE AIR COMPRESSORS • ROCK DRILLS • WAGON DRILLS • DRILL BITS • BACKFILL TAMPERS • SPADERS
PAVING BREAKERS • SHEETING DRIVERS • DRIFTERS • PORTABLE HOISTS • FANS AND BLOWERS • PORTABLE SAFETY LIGHTING

KENNEDY GRINDING

Arctic Iron Ore Plant Starts Operation

Kiruna Facility Will Have 4600 Tph Capacity

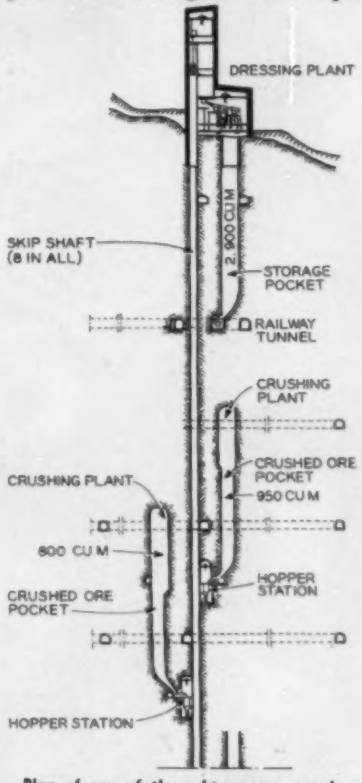
Operations have started at a huge ore-dressing plant in the Arctic iron ore fields at Kiruna, Sweden. When officially inaugurated on Oct. 1 this year, the new plant will represent an investment of more than $10 million. It is to be the largest plant of its kind, and when completed will have eight pairs of magnetic dressing stations—each pair having a capacity of 500 tph.

Open pit mining has been going on at Kiruna and adjoining regions—Europe's largest high grade iron ore deposits—since the end of the last century, but surface mining will cease by 1960. Plans for future use of the ore fields call for a heavy increase in output, from the 1956 high of ten million tons for the entire area to a capacity of 15-20 million tons annually. Highly automated mining methods permit this increase in output without a corresponding increase in manpower.

Capacity 4600 Tph

The 375-ft long, 11-story building, designated the Central Plant, is one of the major technical facilities created in connection with the gradual conversion of the mines from open pit to underground mining. Total capacity of the new dressing plant is to be 4600 tph, or approximately 13 million tons per year. Each pair of the eight magnetic sorting sections is connected with a mine shaft fed by underground crushing stations. At present there are six such stations which reduce pieces of up to 10-12 tons in weight to 4-in. size. Capacity of the primary crushers is 1000 tph, and these have jaw openings of 71x55 in. Ore from the crushing stations first runs down into pockets holding 3000 tons, two to each crusher. Eventually, the number of crushing stations and pockets will be doubled.

From the pockets the ore passes through a hopper station into one of the eight skip shafts. Each skip handles a payload of 20 tons, which is hoisted at 35 fps to the dressing plant. Here the skips are emptied into a system of screens and conveyor belts leading to permanent magnetic cobbers. Five different qualities are produced, ranging in grade from the highest with 68 pct iron and a maximum of 0.03 pct phosphorus, to ore that has a 60 pct iron content and more than 0.8 pct phosphorus.



Plan of one of the subterranean supply sections of the Kiruna ore-dressing plant.

Barren rock, which makes up about 20 pct of the bulk mined, is automatically screened off into different sizes for future sale as various types of single, chippings, or roadbed rock. The stone is then conveyed to silos or deposited on scrap heaps.

Ore Car Loaded in 30 Sec

Pure ore in its turn proceeds down into 12 underground storage pockets, situated directly below the plant. These pockets, about 300 ft deep and holding some 8000 tons each, connect through chutes directly with two railway tunnels which abut on the level of the Kiruna railway yards. The crushed and sorted ore passes by gravity down the vertical chutes and is drawn off directly into rail cars. Each car holds 35 to 42 tons and loading is done in 30 sec. After emerging from the tunnels, trains composed of some 25 cars are sampled, weighed, and shunted into the marshaling yards.

From the yards the ore is hauled by 5000-hp locomotives to the harbors of Narvik on the Atlantic Ocean or Lulea on the Gulf of Bothnia.

The Swedish Industrial Building Co. which erected the dressing plant used a glass wool and aluminum combination for insulation. Winter temperatures at Kiruna often range —20° to —40°F but the building is successfully heated solely from surplus heat of the electric machinery that drives the sorting plant. Over the concrete building has been placed a 4-in. thick layer of plastics-treated glass wool. This in turn has been covered with a thin sheeting of corrugated aluminum to give beauty to a practical requirement.

Potash Project Now Shipping

Shipments of potash were recently begun from National Potash Co.'s new mine and refinery near Carlsbad, N. M. The new facilities took two years to complete and cost approximately $17.5 million. Designed capacity is 400,000 tons of high grade muriate of potash annually.

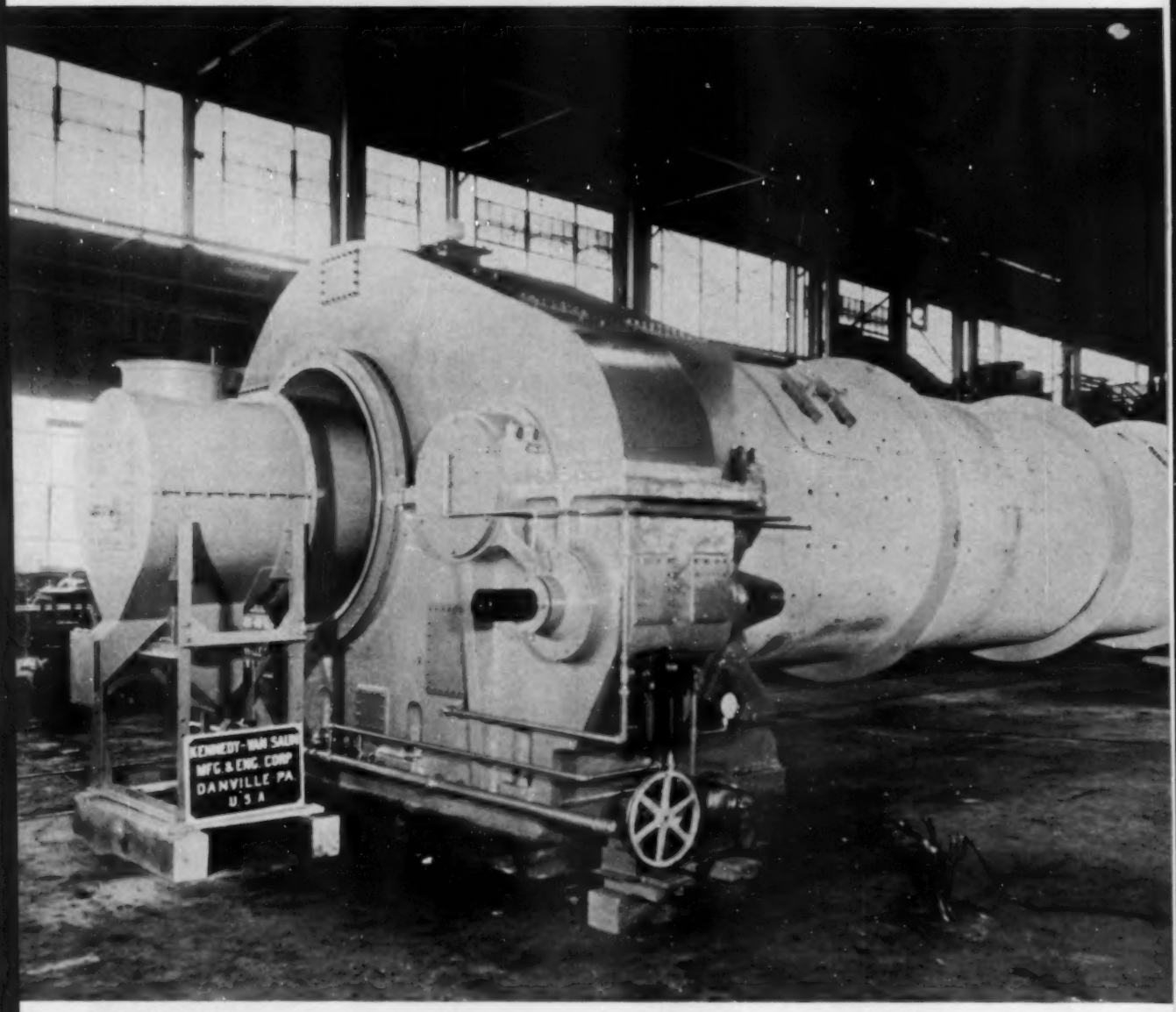
In addition to the refinery, the facilities include two 1800-ft shafts—the deepest in the U. S. potash industry—plus a 21-mile water pipeline. Product storage buildings at the site have a capacity in excess of 100,000 tons. Mining operations are highly mechanized and much of the machinery was specially designed.

National Potash is owned jointly by Freeport Sulphur Co. and Pittsburgh Consolidation Coal Co.

From left to right are the shipping facilities, the product storage buildings, the refinery and the two headframes. The five thickeners are shown in the foreground.

MILLS / *known the world over for*

KENNEDY GRINDING



ONE OF FIVE 8' X 36' KVS INTEGRAL GEAR DRIVE, 3-COMPARTMENT MILLS. BUILT FOR GRESIK CEMENT PLANT, ISLAND OF JAVA, INDONESIA.

FEATURES THAT DISTINGUISH KVS GRINDING MILLS

★ Cast Steel or Meehanite Heads ★ Welded and Stress-relieved Shells

★ Large Diameter Trunions ★ Self-aligning bearings with adjustable Sole Plates

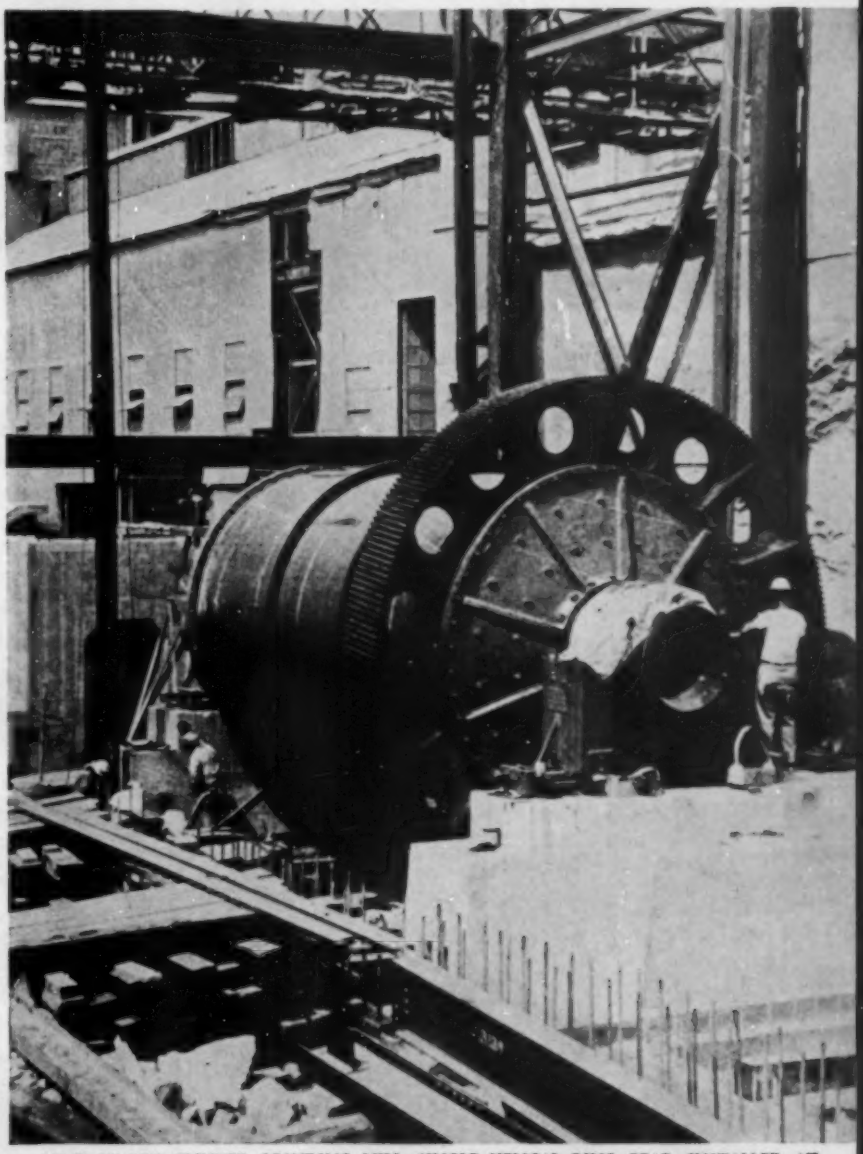
★ Ferris wheel lubrication for main bearings with oil-tight seals

LET OUR ENGINEERING DEPARTMENT FURNISH DATA ON ANY SIZE MILL FOR WET OR DRY GRINDING—

MILLS / *known the world over for performance and dependability . . .*

KENNEDY PRODUCTS

- Gyratory Crushers
- Swing Jaw Crushers
- Tube Mills
- Ball & Rod Mills
- Vibrating Screens
- Rock Feeders
- Air Swept Tube Mills
- Rotary Kilns
- Coolers, Dryers
- Preheaters, Deheaters
- Belts, Conveyors
- Pneumatic Transport Systems
- Waste Heat Boilers
- Pulverized Coal Firing Systems
- Steam Generators
- Asbestos Plants
- Complete Lime Plants
- Complete Cement Plants
- Complete Aggregate Processing Plants

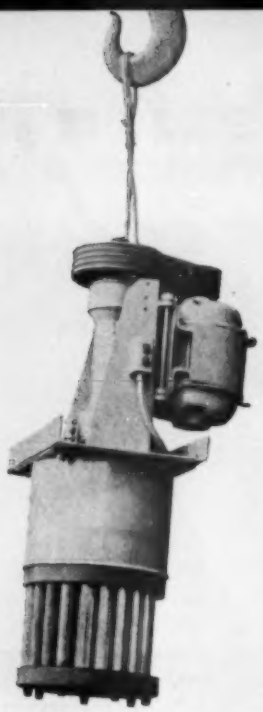


11' X 20' KVS CLINKER GRINDING MILL, SINGLE HELICAL RING GEAR. INSTALLED AT PETOSKEY, MICH., PLANT OF PENN-DIXIE CEMENT CORPORATION.

KENNEDY-VAN SAUN

MANUFACTURING & ENGINEERING CORPORATION

TWO PARK AVENUE, NEW YORK 16, N. Y. • FACTORY, DANVILLE, PENNSYLVANIA



ONE DEAD CELL

but this WEMCO Fagergren still produces

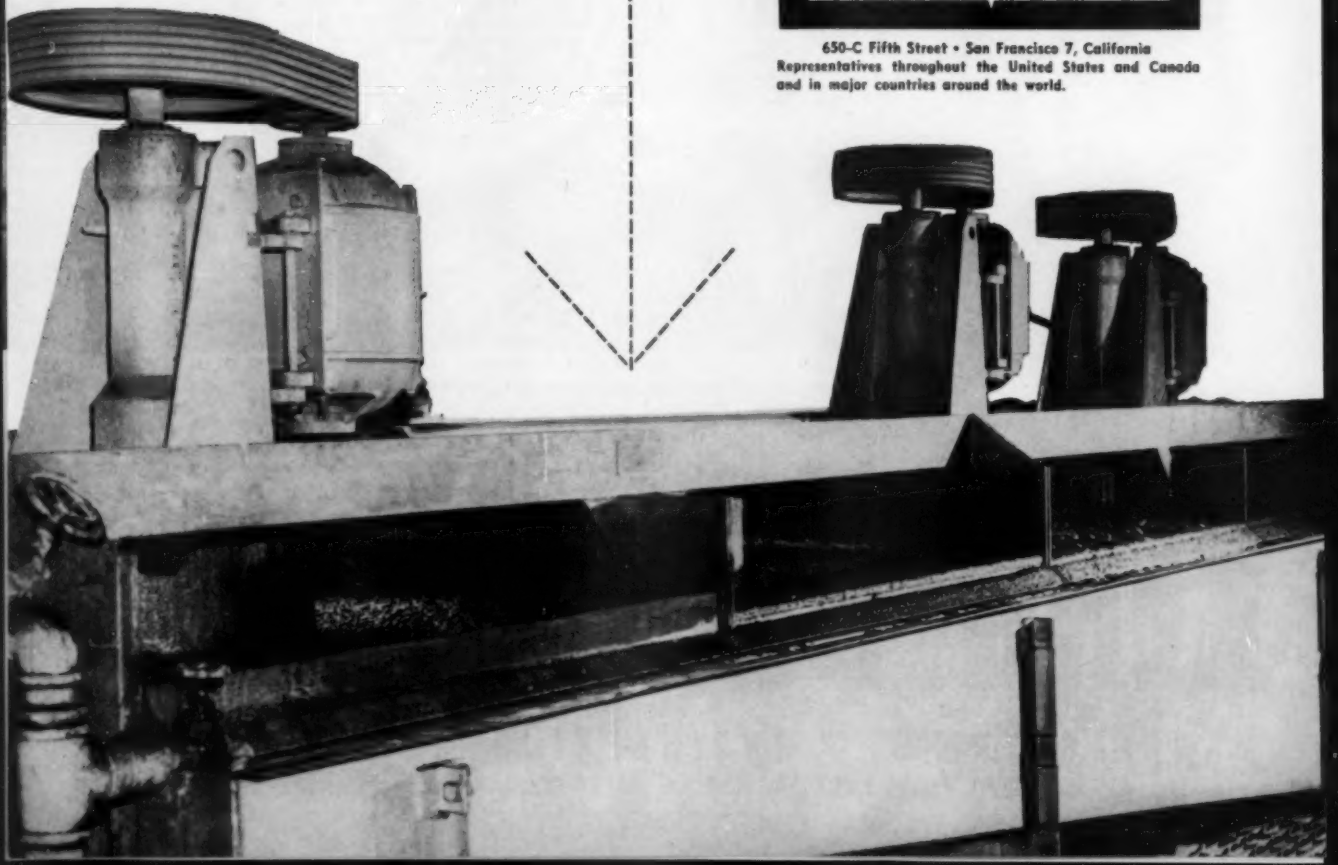
There is no down time when a Wemco Fagergren mechanism is lifted out for service. The bank of cells continues to produce without interruption. Sanding up of the inactive cell is no problem. When the serviced unit (or a spare) is returned, it simply digs its way back into position.

Over half the world's flotation tonnage is produced in Wemco Fagergrens. Operating convenience and easy maintenance are among the reasons both large and small plants choose these machines. High recovery and low reagent consumption are other deciding factors.

For the full facts on how Wemco Fagergren Flotation Machines can *cut your operating costs*, write today for descriptive literature.

WEMCO
WESTERN MACHINERY COMPANY

650-C Fifth Street • San Francisco 7, California
Representatives throughout the United States and Canada and in major countries around the world.



for tough screening jobs . . .

INDUSTRIAL SCREENS

You can depend upon CF&I Industrial Screens to give long service life with little downtime no matter how tough your screening job. That's because CF&I Screens are made from specially selected steel which is crimped and woven extra tightly to assure high production throughout screen life—even when the screens are subjected to severe abrasion, corrosion or high temperatures.

Next time you need an industrial screen, be sure you investigate CF&I Industrial Screens—you'll be glad you did.

SPACE SCREENS

THE COLORADO FUEL AND IRON CORPORATION

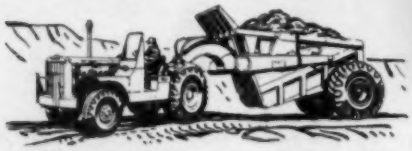
THE COLORADO FUEL AND IRON CORPORATION—Albuquerque • Amarillo • Billings • Boise • Butte • Casper Denver • El Paso • Ft. Worth • Houston • Lincoln (Neb.) • Los Angeles • Oakland • Oklahoma City Phoenix • Portland • Pueblo • Salt Lake City • San Antonio • San Francisco • Seattle • Spokane • Wichita WICKWIRE SPENCER STEEL DIVISION—Atlanta • Boston • Buffalo • Chicago • Detroit • New Orleans New York • Philadelphia • CF&I OFFICE IN CANADA: Toronto

CANADIAN REPRESENTATIVES AT: Calgary • Edmonton • Vancouver • Winnipeg

The Right Size and Type Rear Dump

for every tough mining job!

34-ton capacity PR21 - DW21, for maneuverability in tight quarters.



PR15 - DW15 — fastest, toughest hauler in the 22-ton capacity class.

34-ton capacity PR20 - DW20, for long hauls, high speeds.

New 31-ton Athey Hydraulic Ejection Trailer handles sticky, hard-to-discharge materials.

Name the materials you handle — Rock, earth, overburden, ore — there's an Athey Trailer designed specifically for handling them faster and cheaper than ever before.

Name the tough jobs that beat up haulers — Fast, tough hauls, sloppy footing, big rock, tight quarters — that's the job for an Athey Trailer!

You make your selections from the only *complete* and *proved* trailer line. Select the exact size and features to gear your haul unit to your job. You can depend on them — each Athey Trailer is built to the highest standards of quality, design and construction. And Athey Trailers set the pace for lower cost, fast dumping, greater maneuverability, easier loading and higher production.

Ask your Athey-Caterpillar Dealer for all the facts on the complete line of quality-built Athey products today — he will gladly help you select exactly the right Athey-Caterpillar hauling unit for your mining job. Or write us for literature. ATHEY PRODUCTS CORPORATION, 5631 West 65th Street, Chicago 38, Illinois.

THE *Complete* TRAILER LINE... *by the Leader*

Athey

The real cost of MOTORS

The cost of a motor extends over its entire lifetime. It does not end with purchase price. Cost *goes up* with every shutdown, every motor maintenance stoppage. Cost *stays down* when you buy quality. And quality means Allis-Chalmers.

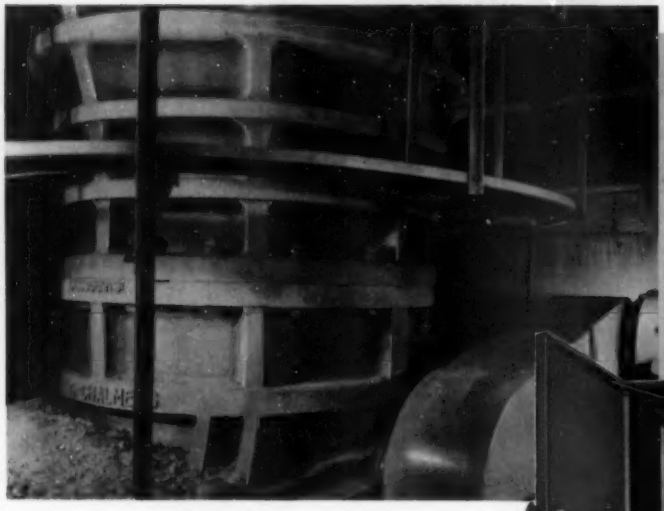
All of these extras that don't show on the Allis-Chalmers nameplate — more copper, more iron, more cooling provisions—exemplify the quality-craftsmanship that goes in before the price tag goes on.

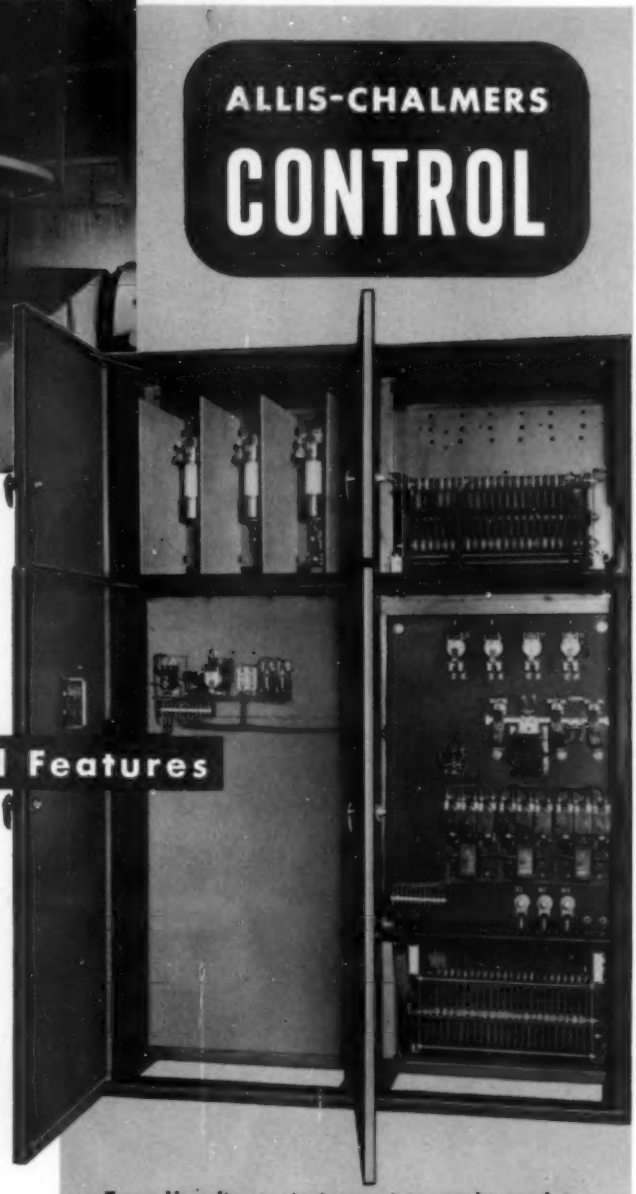
For the "long run," either as a new machinery component or as replacement, specify Allis-Chalmers. Find out more about *real* quality in motors from your A-C district office or distributor, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS

A-5287

custom control cuts crusher downtime





As a leading builder of gyratory crushers for more than 75 years, Allis-Chalmers has expert knowledge of crusher control problems . . . and how best to solve them. Special controls for crushers, developed by Allis-Chalmers, offer important operating and protective features that minimize costly downtime . . . assure continuous, dependable operation.

Control Features

Motor Overload Protection
Two separate sets of thermal overload relays... one set sounds remote alarm horn and energizes warning light at slightest sign of overload. If warning is not heeded, second set of relays stops motor when temperature reaches danger point.

Maximum Torque Starting
Control permits maximum torque starting, when desirable. Maximum torque starting often clears crusher jams.

Jog-Reversing Controller
This feature permits rocking to clear jam.

Time-Delay Undervoltage Relay
Crusher rides through momentary voltage dips.

Stall Protection
Motor is disconnected by instantaneous relay when current is greater than normal peak load.

For detailed information, contact your A-C representative, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

Type H voltage starter custom-engineered to control and protect wound-rotor motors driving primary gyratory crushers.

ALLIS-CHALMERS

A-5206

SULPHUR

helps to create headline products

fluoridated WATER

Some communities will, some won't . . . adopt fluoridation of drinking water for the purpose of reducing tooth decay. The subject is hotly debated but one thing is certain: wherever fluoridation is adopted a derivative of Sulphur will enter the picture.

Several chemicals can be used for fluoridation but they all stem from hydrogen fluoride. To produce this gas, a fluoride-bearing mineral is reacted with sulphuric acid.

As today's Headline Products' are studied, it's significant that so many require for their production one or more derivatives of Sulphur.

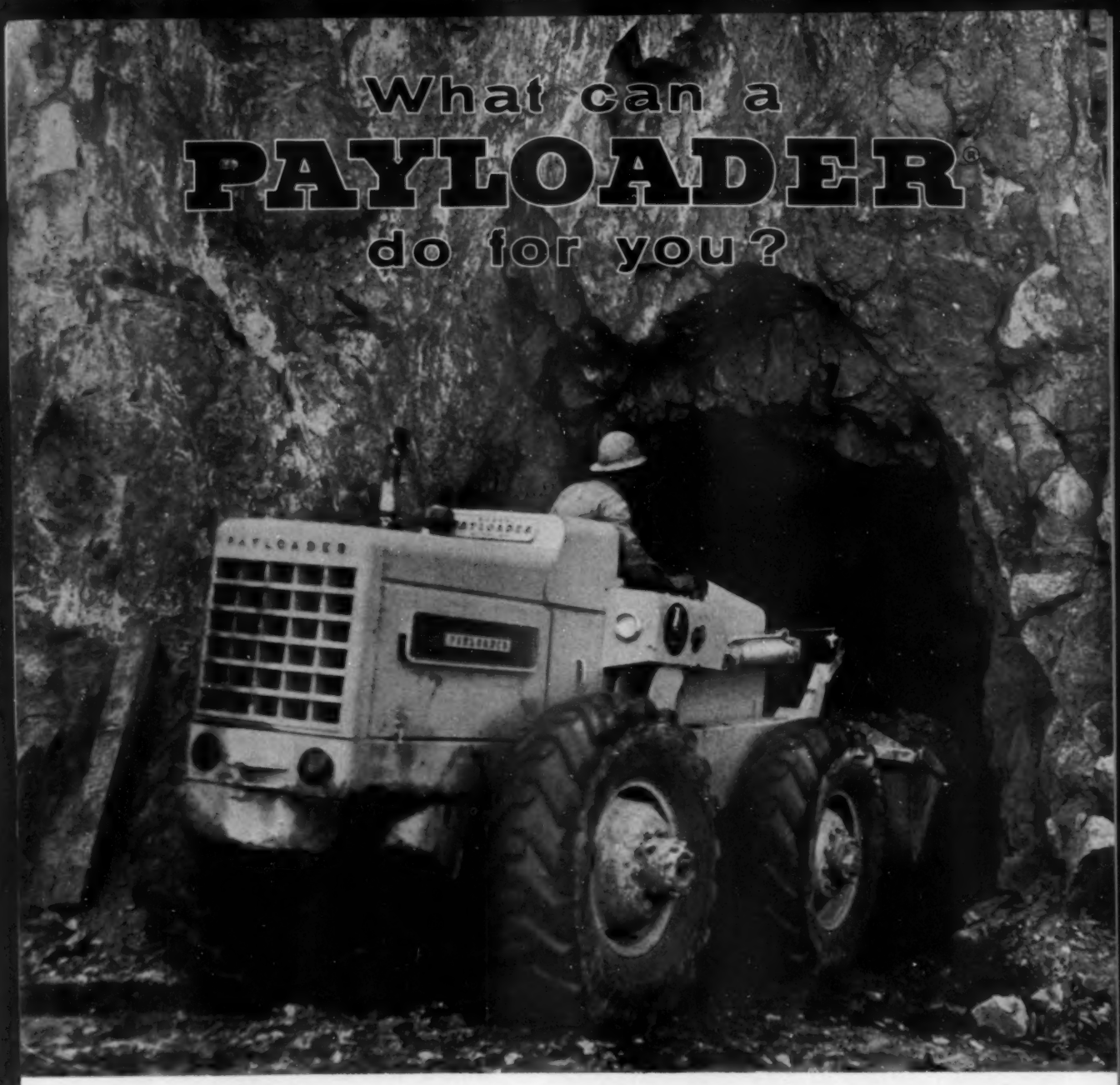
Texas Gulf Sulphur Co.

75 East 45th Street, New York 17, N. Y.

Sulphur Producing Units

• NEWGULF, TEXAS • SPINDLETOP, TEXAS
• MOSS BLUFF, TEXAS • WORLAND, WYOMING

What can a PAYLOADER® do for you?



Versatility — the ability to do many earth and material handling jobs, and ***mobility*** — the speed and ease with which they get to the job, are big reasons for the success and acceptance of rubber-tired tractor-shovels at pits, plants and tipples. Mining men also like rubber-tired equipment because it doesn't chew and grind surfaces and greatly reduces dust conditions.

And among rubber-tired tractor-shovels, none can match the versatility, mobility and productive capacity of the new four-wheel-drive "PAYLOADER" units, size for size.

More reliable traction . . . easier, faster and safer operation . . . greater digging power . . . more carrying capacity, are some of the many outstanding improvements in these four-wheel-drive units that are making friends every day among mining operators who know tractor-shovels best.

Your "PAYLOADER" Distributor wants you to prove on your own work that these new "PAYLOADER" models are the most useful, productive and profitable tractor-shovels you can own. Call him today for a demonstration.

It can strip overburden or clean off veins . . . spread, windrow or stockpile . . . carries its bucket loads and puts them where needed.

It can dig payloads of light *or* heavy materials . . . thanks to tremendous pry-out, break-out force and 40° tip-back of bucket at ground level.

It can spot and switch cars — walk across tracks. Ready pushing and pulling power to boost stalled trucks and skid equipment.

It can load gondolas, trucks, hoppers and conveyors . . . travels fast with heaped loads carried low and close for safety and stability.

Full of "MORE YARDAGE" features

Exclusive power-transfer differentials provide sure-footed traction on mud, gravel, ice and snow.

Hydraulic load-shock absorber cushions the loaded bucket, smooths the ride—permits higher carry speeds with less spillage.

No-stop power-shift transmissions can make ALL shifts on-the-go, under full engine speed. No stopping for RANGE SHIFTS . . . no "clutching".

Powerful 40° bucket pry-out, break-out action . . . Rugged planetary final drives . . . Power steering . . . 4-wheel power brakes.

PAYLOADER®

MANUFACTURED BY

THE FRANK G. HOUGH CO. LIBERTYVILLE, ILL.

SUBSIDIARY—INTERNATIONAL HARVESTER COMPANY

Owners expect more from a "PAYLOADER" and they get more because more of them are in service than all other makes combined. They're designed right and built right . . . they're sold and serviced right by a nearby "PAYLOADER" distributor.

THE FRANK G. HOUGH CO.
916 Sunnyside Ave., Libertyville, Ill.

Send data on 4-wheel-drive "PAYLOADER" tractor-shovels as checked.

- ☐ HO (2¼ yd. payload, 1¾ yd. struck)
- ☐ HH (1¾ yd. payload, 1½ yd. struck)
- ☐ HU (1½ yd. payload, 1 yd. struck)

Name _____

Title _____

Company _____

Street _____

City _____ State _____

59

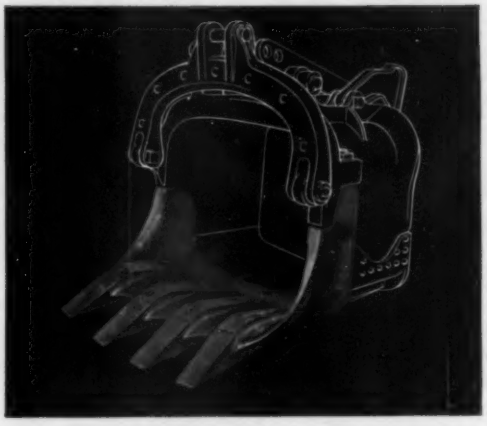
THIS AMSCO® LIP TAKES A SHARPER BITE

. . . chews out full loads at normal power

The lip juts way out where it easily bites up—and delivers—the full yardage of coal. It's a sharp *extension* of the dipper, with fanned teeth—for fast, easy penetration. The dipper digs out a heavier load without strain on the shovel . . . even requires less power, and prolongs life of all parts.

This Amsco lip lasts a long, long time, because it's made of the toughest steel known—manganese steel—the metal that work-hardens to fight off wear by impact and abrasion. Lip replacement is simple, when necessary, keeping downtime short.

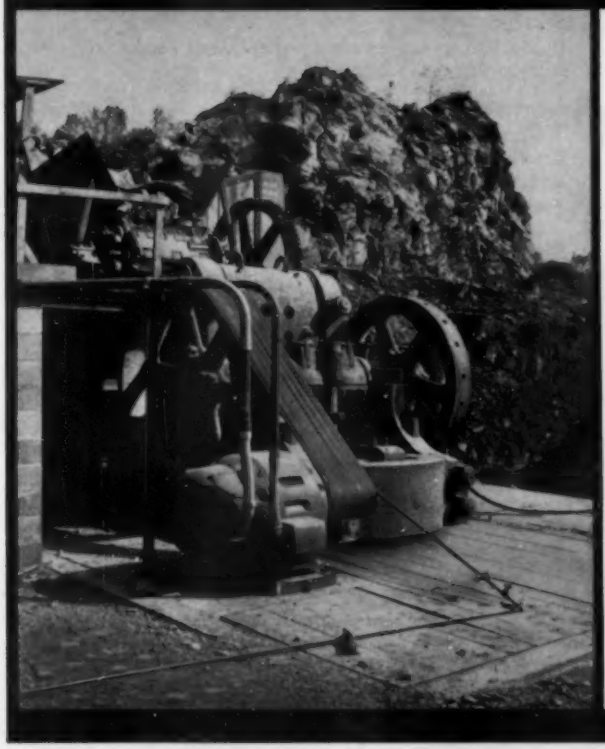
If getting more pay loads moved faster with less wear on equipment means more profits to you, *specify Amsco Renewable Lip Dippers.*



AMERICAN Brake Shoe COMPANY

AMERICAN MANGANESE STEEL DIVISION
Chicago Heights, Ill.

the expert fisherman
has his rod custom-made
because he gets
something **EXTRA**



the profit-wise operator

BUYS TRAYLOR JAW CRUSHERS for the same reason

For over a half a century, producers have specified Traylor-made Jaw Crushers to insure extra hourly production with lower operating costs per ton. There are four types of Traylor-made Jaw Crushers to fit every primary breaking requirement. Feed openings range from 8" x 12" to 60" x 84"; capacities from 4 to 1000 tons per hour. For bulletin on the Traylor Jaw Crusher best suited to your needs, write stating product size and capacity desired.

TRAYLOR ENGINEERING & MFG. CO.
933 MILL ST., ALLENTOWN, PA.
Sales Offices: New York—Chicago—San Francisco
Canadian Mfr.: Canadian Vickers, Ltd., Montreal, P.Q.

the experts agree . . . there's nothing like

TRAYLOR-MADE

equipment for peak performance

A Traylor leads to greater profits

HARD HARDER HARDEST?

WE had no sooner memorized what we thought was the latest of the ultrahard laboratory-made substances the other day than in shuttled a tale of a still harder new material from the labs of General Electric Co. We have already and happily forgotten the old, (which immediately lost all of its glamour) and here cite the new—*Borazon*.

Borazon not only scratches diamonds, it beats the carbon dazzlers in its resistance to heat. Whereas diamonds are consumed in a mere 1600°F, Borazon can stand temperatures that reach over the 3500°F mark.

Combining tremendous pressure with high temperature, as they did in making artificial diamonds two years ago, the GE scientists this time worked with boron and nitrogen which straddle carbon on the table of elements. The result was a cubic form of boron nitride which turned out to be a very different substance from the usual hexagonal variety which is white and graphite-soft.

R. H. Wentorf, Jr., who discovered the material, explains some of the preliminaries this way: "We had a double deterrent; first, there was none in nature to prove that such a thing existed; and second, there were good reasons for believing that it could not be made. In this respect the problem was more difficult than that of making diamond, for we knew all along that diamond could be made because some already existed in nature. All we had to do was find a way. Trying to make cubic boron nitride then, was in a way like trying to catch a new, special kind of fish in a strange lake. You weren't sure whether that lake had any such fish, or whether any lake had such a fish, and the other fishermen were dubious."

Although Borazon is about as hard as diamond, it is no competitor in beauty. Generally the material is black, brown, or dark red, but milky white, gray, and yellow crystals have been made.

Says C. G. Suits, GE vice president and director of research, "We believe Borazon's resistance to oxidation will make possible superior methods of mounting stones in industrial tools and also may allow bits and wheels to be operated at higher speeds."

◆◆◆◆◆◆◆

"NEW technical methods of exploration require more basic training than can be given in undergraduate work," says McGill University in announcing a new course of advanced professional training in mineral exploration. Applicants work two years toward a degree of Master of Sciences (Applied).

According to T. H. Clark, chairman, Dept. of Geological Sciences, "The establishing of this degree, to be awarded for the first time in May 1957, marks a new trend in the training of men for the mineral exploration field, necessitated by the increasing complexity of exploration techniques and the decreasing incidence of outcrop discoveries made by the conventional prospecting methods."

Both mining and geology graduates are eligible. Different courses during the first year bring both to a common level. Second year work is identical.

HIGHLIGHTS of the 1956 achievements of the U. S. Bureau of Mines were recently cited by Secretary of the Interior F. A. Seaton. The following roundup includes a large number of the most significant attainments. More complete and detailed data is publicly available in the Secretary's annual report.

Base Metals

Copper deposits in Washington and Alaska were sampled by field crews. Copper recovery from oxide and oxide-sulfide ores was improved.

Invention reports were filed on a vertical amalgam electrode and a new chloride electrolyte for recovering pure metallic zinc from galvanizer's residue.

Methods were devised for treating complex Alaskan mercury-antimony ores.

Nonmetallic Minerals

Planer-mining on some domestic phosphate rock was found advantageous. Modifications were found necessary on a Bureau-designed continuous mining planer.

Clay resources were evaluated, particularly in Washington, Idaho, Colorado, and Utah.

Advances were made on substitutes for strategic muscovite block mica, including reconstitution of flake synthetic mica into sheets.

Research was conducted on recovering fluorine from phosphate rock.

California and Maine asbestos deposits were examined and progress was made toward making synthetic asbestos fibers.

Quality of water required by processing plants and the mineral constituents of waterborne wastes were emphasized in a new study of water problems of the mineral industry.

Survey was made of future cement-production capacity and availability of aggregates for the national highway program.

Ferrous Metals and Ferroalloys

More than 900 Lake Superior taconite samples were classified. Ore-dressing tests were made on lowgrade iron ore from Texas, the Southwest, and the Pacific Northwest, and on titanium-bearing iron ore from Alaska.

Studies were made of high temperatures in steelmaking and the effects of boron and rare earths on physical properties of steel.

Work on manganese included progress in upgrading domestic lowgrade ore, delineating an extensive deposit in Arkansas, and discovering that within limits, titanium can be substituted for manganese to counteract harmful effects of sulfur in steel.

Light Metals

Aluminum-silicon alloys were produced experimentally by smelting offgrade domestic materials not now suitable for alumina production, and commercially pure aluminum was made from them in the laboratory.

Further information was gained on producing alumina from Wyoming anorthosite rock.

Rare Metals

More than 24,000 mineral samples submitted by prospectors were analyzed for the AEC.

Also for AEC, research was conducted on thorium metal, rare earth alloys, and beneficiation and hydrometallurgy of uranium ores, including certain uraniferous lignites.

Success of USBM in recovering columbium and tantalum from tin slags and domestic ores led a private company to build a pilot plant for treating columbium-tantalum concentrates.

Bituminous Coal

Alaskan coal deposits were explored and a permanent coal-testing laboratory was established at Anchorage.

Domestic mining methods and equipment were appraised. Studies included modified longwall mining with planers and use of large augers in surface operations.

Flow patterns of gases and dusts in combustion equipment and the pneumatic transport of solids were studied as the first phase of a newly-begun fluid dynamics research project.

Fundamentals of the Fischer-Tropsch process for making synthetic liquid fuels from coal were studied; catalysts giving high-quality gasoline and those giving high yields of gasoline were evaluated.

Studies were made on costs and construction materials for using nuclear energy in coal gasification. Tests with two simulated (electrically heated) reactors indicated possibilities of reducing cost of both synthesis and pipeline gases made from coal.

Cooperative study of underground gasification of coal progressed, and an industry advisory committee was established.

Anthracite

A Bureau-designed pneumatic planer showed that the hardest anthracite can be planed.

An anthracite briquet for metallurgical fuel showed impact and abrasion resistance comparable with furnace or foundry coke.

Explosives

More than 3000 tests of permissible and other explosives and hazardous chemicals were made.

Consumption of permissible explosives rose to 90,338,390 lb from 78,490,751 lb the preceding year. At year's end 180 different permissibles were on the active list.

Techniques were devised for neutralizing the explosion hazard of parked mine cars loaded with fine coal.

Health & Safety

Mine roof support and rock bolting studies included efforts to systematize use of compression pads, tests of new bolts, and centrifuge studies of rock specimens.

Culminating years of research, safety standards were adopted for certifying conveyor belts as fire-resistant and approving power-circuit-fed lighting systems as permissible for use in underground coal mines.

Some 25,000 persons completed the 20-hr accident prevention course for coal miners, bringing the number trained since 1947 to 150,000.

Foreign Activities

Concentrating on assuring a continued flow of strategic and critical minerals from abroad, information was collected and evaluated on the extent, development, and metallurgical problems of foreign deposits. These facts were made widely available.

Bureau engineers were assigned to 15 technical assistance projects in 13 foreign countries.

Sixteen foreign trainees completed assignments at Bureau laboratories in the U. S.

◆◆◆◆◆◆

DOMESTIC fluorspar tonnage shipped dropped 15 pct since 1950 even though U. S. consumption climbed 40 pct during this period. This contrasting state of affairs was brought to the attention of the industry in remarks by J. Blecheisen, president, Rosiclare Lead & Fluorspar Mining Co. at Denver on February 9, this year.

He pointed out that domestic units shipped 70 pct of total U. S. consumption in 1950, but by 1956 this volume sank to 40 pct. Although domestic mines shipped 260,000 tons in 1956, (excluding shipments to government stockpile) consumption of all grades reached a total of 600,000 tons.

This producer estimates that fluorspar consumption will be 900,000 tons in 1960. Steel consumed about 250,000 tons in 1956; aluminum took about 100,000 tons; hydrofluoric acid used 175,000 tons; and the ceramics, glass, and miscellaneous users corraled the remaining 75,000 tons.

The greatest consumption rise since 1950 has been in hydrofluoric acid which soared from the 75,000 tons then used. Aluminum's use of fluorspar about doubled during the same period, but steel employed only about 10,000 tons more in 1956 than in 1950.

The major producing area for more than 75 years has been the Kentucky-Illinois. This section supplied 60 pct of domestic fluorspar last year. Approximately 25 pct came from Colorado, and 15 pct from Montana, Utah, and Nevada.

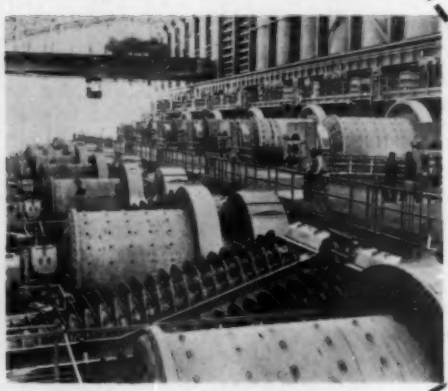
Almost 60 pct of the 525,000 tons imported was drawn from Mexico. Other suppliers were Canada, Spain, Italy, and West Germany.

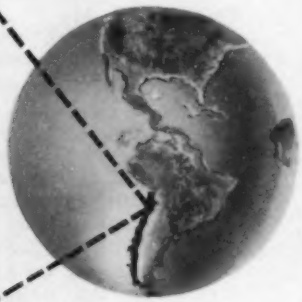
What is the fluorspar industry doing about the uneven picture? Mr. Blecheisen notes that an ODM application filed in June 1955 was withdrawn conditionally in November 1956 when it appeared that the government might start stockpiling and other corrective steps toward improving the situation. Government acquisition of metallurgical grade fluorspar began in the summer of 1956, and the acid grade program was launched in the fall of 1956.

The domestic reserve picture is much improved. Geological Survey finds that estimates are greater today than in 1944, even after the mining of 15 million tons since that time. The latest studies show reserves of approximately 22.5 million tons of plus 35 pct ore, and approximately 12 million tons of 15-35 pct ore.

I saw them in Chile, too!

YES, WHEREVER THERE'S MINING, you'll find the successful companies using **Marcy Mills.** The fact that these companies throughout the world continue **reordering** Marcys is evidence of Marcy's low-cost-per-ton production and dependable mechanical operation.





Twelve 10' x 10' Marcy Ball Mills, six 6' x 12' Marcy Ball Mills and twelve 10' x 14' Marcy Rod Mills at Chile Exploration Company, Chuquicamata, Chile. In addition to these 30 mills there are approximately 50 additional Marcy Mills in Chile.

One reason...

Marcy principle of grinding increases tonnage up to 33%

"Rapid change of mill content is necessary for high efficiency" . . . that's the Marcy principle of grinding. It is accomplished by use of **full-grate** discharge on Marcy Ball Mills and the **open-end** feature on Marcy Rod Mills.

In seven representative installations where overflow mills were converted to Marcy Grates the average increase in tonnage was 33.6% with an average decrease in power of 0.95 KWH per ton.

NO EXTRA CHARGE FOR MARCY® EXPERIENCE

THE MINE AND SMELTER SUPPLY CO.

DENVER NEW YORK SALT LAKE CITY EL PASO

SALES AGENTS AND LICENSED MANUFACTURERS THROUGHOUT THE WORLD

CYANAMID

REAGENT NEWS

"ore-dressing ideas you can use"

Now Commercially Available-- A More Economical Flocculant AEROFLOC® 550 Reagent

Cyanamid is pleased to announce a lower-priced, efficient flocculant —AEROFLOC 550 Reagent—to replace both AEROFLOC 548 and 552 Reagents with consequent savings to its customers.

Extensive laboratory testing and plant usage have indicated that AEROFLOC 550 Reagent is just as effective a flocculant as the products it replaces. In addition, increased production and improved manufacturing techniques have made possible substantially lower prices on AEROFLOC 550 Reagent—in the 58¢ to 63¢ per pound range, F.O.B. Woodbridge, New Jersey or F.A.S. New York, depending upon quantity and packaging.

Chemically AEROFLOC 550 Reagent is the same synthetic polymer as AEROFLOC 548 and 552 Reagents. It also has similar physical properties. Performance-wise AEROFLOC 550 Reagent is equal to or better than AEROFLOC 548 and 552 Reagents. Consequently, no changes in feed rate, solution strength or other operating procedures are involved in the change to AEROFLOC 550 Reagent.

AEROFLOC 550 Reagent is most effective on slime suspensions having a pH of 5 or above. For acid circuit flocculation, AEROFLOC 3000 Reagent is recommended.

Cyanamid field engineers will be pleased to furnish samples for test and to quote upon your requirements.

AMERICAN CYANAMID COMPANY

MINERAL DRESSING DEPARTMENT

30 ROCKEFELLER PLAZA, NEW YORK 20, N. Y.

NORTH AMERICAN CYANAMID LIMITED
160 Bloor Street East,
Toronto 1, Ontario, Canada

CYANAMID DE MEXICO, S. A.
Apartado No. 20018, Mexico 12, D. F., Mexico

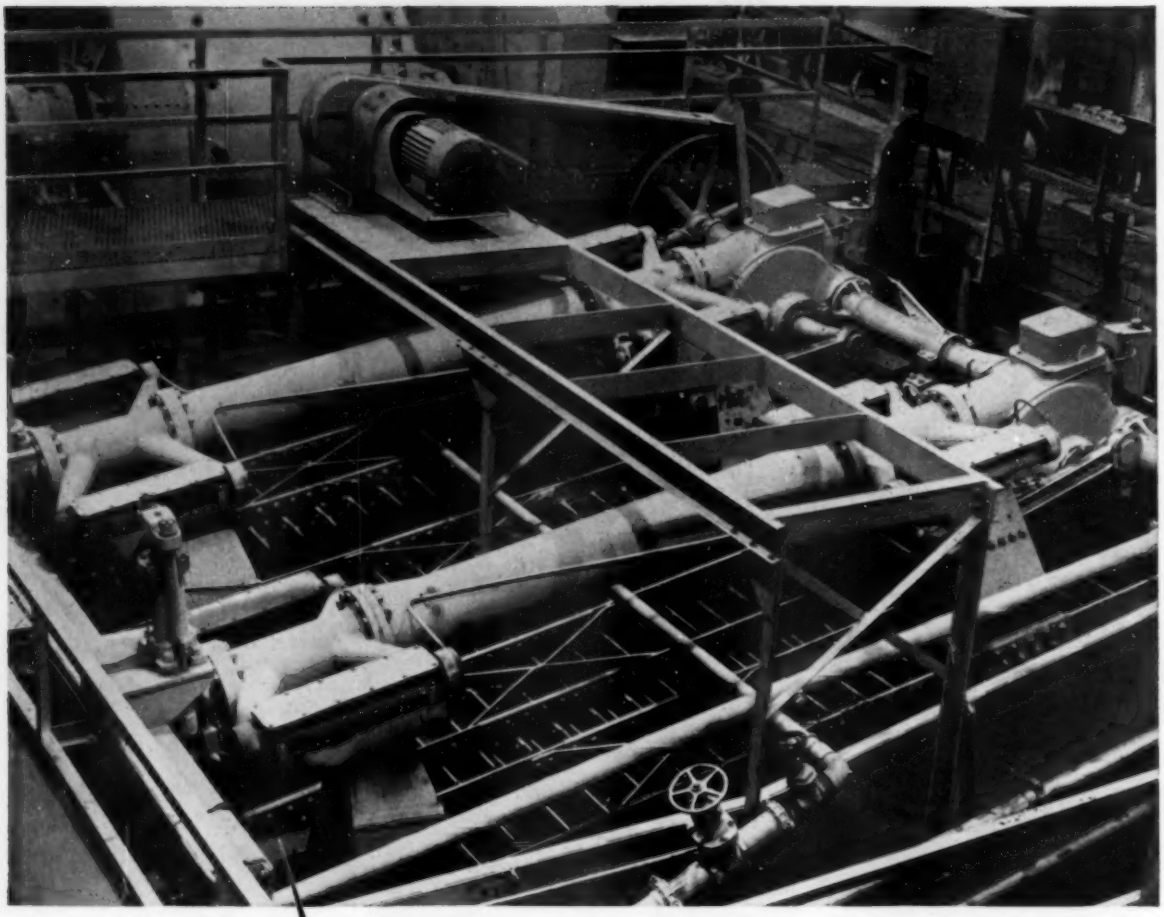
CYANAMID OF GREAT BRITAIN, LTD.
Bush House, Aldwych, London W. C. 2, England

SOUTH AFRICAN CYANAMID (PTY.) LTD.,
P. O. Box 7558,
Johannesburg, Union of South Africa

E. P. CADWELL, Reina 1043,
Of. 6, Lima, Peru

G. B. O'MALLEY
377 Little Collins St.,
Melbourne C. 1, Australia

Cable Address — Limenitro, New York



Idarado Mining Co. Classifies Complex Ore Body with DORR heavy duty Classifier

Rocky Mountain Mill Beneficates 1750 TPD of complex ore containing copper — lead — zinc — gold & silver

Situated high in the Rocky Mountains in Colorado almost 9000 feet above sea level, the Pandora Unit of the Idarado Mining Company has encountered one of the most complex ore bodies in the Western United States. Consisting mainly of copper, lead, and zinc sulphides, the ore also contains recoverable fractions of gold and silver.

In the Pandora flowsheet an 8′ x 12′ rod mill receives 1750 TPD of minute 1″ copper-lead-zinc-ore. The rod mill discharge is jigged to recover gold and silver which is then sent to amalgamators. The balance of the rod mill discharge, which is approximately 30% minus 65 mesh, overflows to the Dorr Quadruplex Classifier. The Dorr Classifier, which is 16′ wide by 28′ long, is in closed circuit with ball mills and produces a 65 mesh separation at an overflow solids concentration of 35%. Overflow product goes to a conventional flotation circuit for subsequent recovery of the copper, lead, and zinc values.

For more information on Dorr HX Classifiers, write for a copy of Bulletin No. 2281. Dorr-Oliver Incorporated, Stamford, Conn.

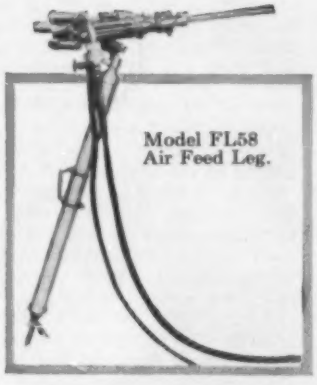
DORR-OLIVER
INCORPORATED
WORLD-WIDE RESEARCH • ENGINEERING • EQUIPMENT
STAMFORD • CONNECTICUT • U.S.A.

Horizontal drilling with Air Feed Leg mounted sinker.

Less time to set up and tear down with Gardner-Denver air feed leg

Recommended to replace jumbos in smaller headings and inaccessible workings. No time wasted in setting up columns or crossbars. One man brings Air Feed Leg mounted drill into position and starts drilling.

- Adjustable feed leg pressure provides proper feeding in horizontal or up-hole drilling
- Controls conveniently located on backhead
- Push-button air release in feed leg
- Automatic water gland for water-on, air-on, air-off, water-off cycle
- Constant chuck-end blowing stops cuttings from entering drill
- Piston rod wiper excludes dirt
- Supports drill in rigid stoper bracket for up-hole drilling
- Drill easily removed for use as sinker



Model FL58
Air Feed Leg.

WRITE FOR BULLETIN

ENGINEERING FORESIGHT—PROVED ON THE JOB
IN CONSTRUCTION, MINING, PETROLEUM AND GENERAL INDUSTRY

GARDNER-DENVER

Gardner-Denver Company, Quincy, Illinois
Gardner-Denver Export Division, 233 Broadway, New York 7, New York
In Canada: Gardner-Denver Company (Canada), Ltd., 14 Curity Avenue, Toronto 16, Ontario

A Report on the State Of

by C. E. Reistle, Jr.

I FIND words inadequate when I try to tell about the wonderful experiences, new friends, and things I have learned about the mineral industries as President of the Institute. However, I feel somewhat like an older friend of mine who reluctantly took his first airplane ride with me. That night in the hotel room, he looked up and said, "You know, I think air transportation is here to stay." I have the same feeling about our Institute and engineering in the mineral industries. We are here to stay.

During the year I had the pleasure of visiting 36 Sections and Subsections extending from Alaska to Florida and from Boston to San Francisco; the fall meeting of the Petroleum Branch in Los Angeles; the Electric Furnace Steel Conference in Chicago; the joint meeting of the Colorado MBD Subsection and the Pikes Peak Section in Colorado Springs; the Rocky Mountain Minerals Conference in Casper; the Institute of Metals Division in Cleveland; meeting of the Pittsburgh Section and the National Open Hearth Steel Committee in Pittsburgh.

Frankly, until this year I had very little idea how the other segments of the Institute actually functioned as compared to my own Gulf Coast Section and Petroleum Branch. Believe it or not, no two function alike. In fact, there is very little similarity between them except for having a standard administrative setup. However, each functions in accordance with the wishes and needs of its particular members. Some are undoubtedly more effective than others. I am convinced that all can be improved and that the new national organization setup will provide for stronger Sections and greater service to the individual members.

It is my firm belief that the Local Sections are the most important part of our Institute. The three new Societies and the National Institute can only justify their existence by rendering a service to these Sections and their individual members.

Where AIME Stands

But before I discuss the organization and problems of the Institute, I would like to report on internal health of the Institute.

First, financially we have had a satisfactory year. The Institute has been able to carry on expanded activities much greater than ever before undertaken, such as more regional meetings and a larger volume of published technical papers, and, at the same time, has lived within its budget.

During 1956 the three Branches published in their journals 325 technical papers comprising 1600 pages. In addition, these papers will be published in the Transactions of each Branch.

Our year was also satisfactory from a financial viewpoint. Our total income amounted to $874,968 and our expenses were $860,856, leaving a surplus of $14,111. I might add that each Branch of the Institute operated within its income and contributed almost equally to the surplus of $14,111. Our endowment and custodian funds now amount to $1,552,684, an increase of $129,047. This represents the value of our investments at cost to us, and they have a greater value on the present day market.

Our interest in real estate and other assets of United Engineering Trustees is valued at $491,642. A more detailed discussion of these items can be found in the official AIME Annual Report.

Secondly, membership has grown at a remarkable rate. Much credit for this fine growth is due to the activities of our membership committee. During the year, our total membership grew from 26,548 to 29,713, an increase of 3,165 or 12 pct. The percentage loss in membership, excluding Student Associates, due to suspensions, resignations, and deaths is lower than any of the preceding three years and amounted to only 4.4 pct as compared to 5.4 pct in 1953.

It is estimated that there are 240,000 members in the professional engineering societies affiliated with Engineers Joint Council. Our membership constitutes 12.4 pct of this total. It is obvious that our membership represents a large segment of the professional engineers in this country.

Third, the number of Local Sections has increased from 69 in 1955 to 73 in 1956. As I mentioned previously, I feel that our Local Sections are the most important part of our internal organization.

Your Board of Directors this year has devoted its time principally to the consideration of two problems. The first and most important of these being a study of the Institute's organization. Secondly, a study of the problem of selecting a new headquarters site for the Institute and its fellow Founder Societies.

The New Structure

As a result of its work on the first problem, the Board on Sunday, February 24, adopted new Bylaws for the Institute. These Bylaws provide for the Institute to be divided into three Societies: the Society of Mining Engineers, the Metallurgical Society, and the Society of Petroleum Engineers. These Societies replace the three Branches of the Institute. In addition, the Board approved the Bylaws of each of these three Societies with the understanding that certain changes may be made in these Bylaws by the Board of Directors of the Institute from time to time either upon recommendation of the Society or the Board of Directors of the Institute in order to maintain an effective organization. It is clearly understood that the solution of any unanticipated problems—and I am sure that we will have some—must be approved by the Board of Directors of the Institute.

The new Bylaws also provide for continuation of the Council of Section Delegates, which was recognized as a strong and constructive force in Institute affairs. Provision is also made for a Council of Education and a Council of Economics so that our vital interest in these two subjects can be given proper consideration.

I feel that this new organization can best be compared to a new plant, a new model automobile, or a new company—there are bound to be unanticipated problems. The future of the Institute depends upon how well we meet and solve these problems.

The Board of Directors also gave careful consideration to the selection of a new headquarters site. This problem was most difficult because it was necessary to work with the other Founder Societies through the

The Institute

(Presented at the Annual Meeting All-Institute Technical session, Tuesday, Feb. 26, 1957, at New Orleans.)

mechanism of the United Engineering Trustees, and select a site that was mutually acceptable to all. I would be remiss indeed if I did not acknowledge the generous offers and interest displayed by various groups of civic-minded people in New York, Pittsburgh, Philadelphia, Chicago, Washington, D. C., Shreveport, St. Louis, and Kansas City. Each of these cities paid the engineering profession high praise in offering to make substantial contributions to a new engineering center.

A New Headquarters

The responsibility of representing AIME on the special Task Committee of the Founder Societies and AIChE was placed in the hands of our most able and respected immediate Past-President, Henry DeWitt Smith; Harold Decker, a Vice President of the Institute; and Clyde Williams, also a Past-President. I cannot pay Henry DeWitt Smith too great praise for the outstanding leadership he displayed in reconciling the emotional factors that were generated in the consideration of this problem.

This Committee had its first meeting on Oct. 10, 1955, and on June 22, 1956, brought in the following report:

► The Engineering Societies Center be located in New York City.

► The 39th-40th Street site be continued in use as the site of the Engineering Societies Center.

If rebuilding in that area proves impracticable, a comparable site should then be sought in midtown New York.

We suggest that the governing boards also adopt these further recommendations for inaugurating action:

► The United Engineering Trustees Inc. be authorized to take proper legal action for expansion by the addition of the American Institute of Chemical Engineers to the incorporators when properly qualified.

► The United Engineering Trustees Inc. be authorized to raise money and accept contributions; accept the offer of the Kelly Committee—quoting from Dr. M. J. Kelly's letter, his Committee made the following commitment: "We assure you that a well organized, diligent, and competent effort will be made and continued until the required sum is available"—place contributions in UET capital fund assets; employ architects, engineers, and attorneys; let contracts for reconstruction of the present Engineering Societies Building and/or a new building or buildings; pay all costs out of the capital fund assets; and operate and maintain the new Engineering Societies Center.

► The plans for the new and enlarged Engineering Societies Center be made with ample optimism with respect to the future growth of the five Societies immediately involved. These facilities should be such as to attract and hold all of the engineering profession, thus fostering unity and cooperation along broad lines.

The Four Societies constituting United Engineering Trustees Inc. (AIME is one of these four Societies) approved the above recommendations by the end of September 1956. The American Institute of Chemical Engineers approved recommendations 1 and 2 and signified its desire to become a member-body of UET Inc. By the end of November 1956, UET and its four member Societies had agreed upon arrangements by which AIChE would become a member-body of UET Inc.

Progress, Plans, and Proposals

The first important problem facing UET was to determine the feasibility of developing the present building site on West 39th Street in cooperation with the Engineers' Club which faces 40th Street. Shreve, Lamb & Harmon Assoc. were retained as architects and they submitted two proposals at the end of November 1956. One proposal visualized razing the present structure and erecting a new building. The New York City setback ordinances made it impossible to carry out the plan satisfactorily and it was rejected. The second proposal visualized using more of the present building envelope but reconstructing the interior, enlarging and modernizing it, and erecting a building in access space to 40th Street on the assumption that the necessary land could be secured from the Engineers' Club. The proposal included two stages, the first providing 189,000 sq ft of net usable space on the present site and the Club land; the second adding 53,000 sq ft by taking additional property on 39th Street. This proposal was submitted to two reputable construction companies for cost estimates. The two estimates, received late in January, were very close, and revealed that the cost of rehabilitation was so high that the use of the present site seemed unwise. The reconstruction would require moving out, thus adding additional costs of moving out, rent at commercial rates for from 1½ to 2 years, and moving into the rehabilitated building. These cost factors and the fact that the result would be a remodeled makeshift that would not provide an attractive reason for securing new funds were discussed at two meetings of UET Inc., and on Feb. 12, 1957, the trustees decided to abandon plans for the present site and to seek a new one. Active steps are under way to that end.

In June 1955, Dr. M. J. Kelly, president of Bell Telephone Laboratories Inc., organized a committee of engineering leaders in industry and education which offered to aid the new Engineering Center by raising construction funds. Upon the approval of the recommendation of the Task Committee, UET Inc. immediately invoked the aid of Dr. Kelly and his committee. Dr. Kelly responded by organizing his fund-raising program, which he hopes to have under way before summer. To do so, the site must be selected and firm floor space needs determined for the occupants of the present building and for other societies who wish to take space in the new building. The deadline for these determinations is Apr. 1, 1957.

(Continued on page 424)

Looking Ahead

Now, looking into the future, I would like to suggest that the Board of Directors and members of the Institute give careful consideration and take steps to accomplish certain objectives. First, I think it is imperative that each member of the Institute accept in a constructive manner the new organization. That we be tolerant and act with mature judgment in correcting and adjusting the organization so that we may continue to render maximum service to the individual member in his need for professional engineering knowledge and social contacts. That we dedicate ourselves to preservation of the national organization—AIME—so that we may perpetuate and provide dynamic national leadership for all engineers in the mineral industries.

Secondly, today we find many members of the engineering profession demanding that society give the engineer greater recognition. It has been my experience that each of us, either as individuals or acting collectively as companies or professional societies, receives recognition not as we demand but as we deserve. There is no doubt that many people know little or nothing of the professional engineer. In the first place, the word engineer is applied to so many kinds of people, from the fellow who tends the apartment house boiler to the man who drives the locomotive to the draftsman over the drawing board and on up. Small wonder that when professional engineers start to claim special status, the ordinary citizen cannot imagine what all the rumpus is about. Furthermore, almost any group can get together and call themselves this or that engineering society.

Here I would like to quote from a recent speech of my good friend, Dr. W. K. Lewis, Professor Emeritus, Massachusetts Institute of Technology:

> "However, the important thing is not what the public thinks about us, but what we think, or ought to think, about ourselves. From this point of view, I feel there are two vital matters in which we fail to measure up to full professional stature. The first of these engineering shortcomings is that, while recognizing our social responsibility in the public interest, we interpret that responsibility far too narrowly. Any group aspiring to full professional status must accept responsibility for leadership in every phase of its area of specialization. Thus, the physician is interested not only in the health of the patient, but in every sort of activity related to health, curative and preventive, public and private. Unfortunately, this is not true of engineers. For example, the production of goods has its human as well as its technical side. In technical matters the engineer is perfectly willing to be held accountable, but his attitude as an engineer is that the human phases of production are none of his business. If the engineer hopes to secure acceptance of his professional status, this attitude must change.
>
> Unfortunately, there is still further evidence that engineers are mere technicians. Medicine is fully as specialized as engineering, yet the medical profession has its great professional society, to which its organization of specialists are subsidiary. We engineers, on the other hand, have our societies of civil and mechanical, of electrical and metallurgical, of chemical and aeronautical engineers. The only things that differentiate these groups are techniques. Our very organizations demonstrate our lack of breadth in professional outlook.
>
> Efforts have been made in the direction of correcting the situation, but they are feeble. We have our state and national societies of professional engineers, but these are merely associations of individuals licensed (registered) by the state, and such a license is the qualification for membership. We have the Engineers Joint Council, but this is too weak to speak with authority for the profession as a whole. Their organization bears about the same relation to what is needed as the Articles of Confederation between the Colonies bore to our American Constitution. If engineering is to get the general recognition it desires, it must first achieve for itself a sense of its own unity and give effective organizational expression to it."

Recognition for the Profession

The need Dr. Lewis points out has been obvious to many engineers for some time. ECPD must be given credit for initiating a movement to make a broad survey of the engineering profession in an effort to solve the problem. As a result, in January of 1956, EJC authorized a joint committee with ECPD to explore the question as to whether or not a survey of the engineering profession should be made.

This ECPD-EJC joint committee made the following recommendations in September 1956:

1) They endorse the proposed survey of the Engineering profession as outlined in their report dated September 1956.

2) They endorse the establishment of a joint ECPD-EJC committee on a survey of the engineering profession.

3) They recommend that funds be authorized for the initiation of the survey. Once solid support on the part of the societies is demonstrated, there is indication that other sources will provide substantial underwriting. An immediate subsidy of $50,000 from the societies is suggested.

Your Board of Directors has authorized an expenditure of $7500 as AIME's proportionate part of this proposed expenditure. It is estimated that it will cost on the order of $1 million and require at least two years to make a survey of the engineering profession.

The joint committee of EJC and ECPD suggests the establishment of "a committee on the survey of the engineering profession under the joint auspices of ECPD and EJC." I think it is time for us to recognize that the National Society of Professional Engineers, and I might add that I am not a member of this Society, is also a vital force in the engineering world. I would suggest that they also be included in this group effort or study.

But it is even more important, in my opinion, that the Board of Directors of the Institute take a definite and constructive part in this proposed activity. Furthermore, steps should be taken to keep the membership fully informed by regular reports in the journals of the Institute. One of the great weaknesses of EJC and ECPD in my opinion is that the rank and file members of the member societies have little or no knowledge of the plans or actions of these two organizations. On the other hand, the NSPE has *representation from the "grass root" level* and can act with force and knowledge of the entire membership.

I recommend that a strong and active Board committee be formed in our Institute to study, review, and guide our activities in ECPD and EJC. Also, that our representatives in these two organizations work in cooperation and under the guidance of this committee. Furthermore, this committee should keep the Board of Directors fully informed of their actions. In turn, the Board of Directors should provide a means of informing the Sections of their actions and obtain counsel from the Sections of the Institute. Perhaps there is a better way to do this, but I at least feel it is my duty to call the problem to your attention, hoping that as a result we can take full advantage of this proposed study. Otherwise, I am afraid that we will have another fine report about the engineering profession known only to a few, and completely ineffective due to absence of knowledge and understanding by the 240,000 engineers affiliated with us in the Engineers Joint Council.

Two sets of joints are well developed. One strikes N 65° E and dips 80° to the south; the other strikes

changed to anhydrite. Some support is given this view by the presence of a small gypsum deposit

Quality Control In Selective Mining of Magnesite

Chemical contour plots solve problems in mining several grades of magnesite in a complex geologic setting at Gabbs, Nev.

by Conrad Martin and H. P. Willard

SINCE the deposits were found in 1927 in the Paradise Range of western Nevada, more than 1 million tons of magnesite and half a million tons of brucite have been mined and processed into a variety of granular refractory materials used as furnace linings by the steel industry. An additional million tons of magnesite were used during World War II to produce magnesium metal, and some magnesium oxide from the area is going into magnesia cements.

Located near Gabbs, Nev., on the west flank of the Paradise Range, the principal bodies occupy an area a mile long by half a mile wide, and lesser occurrences have been found in a belt more than four miles long and in places almost two miles wide. Magnesite reserves containing less than 5 pct lime are estimated at more than 25 million tons. Reserves of better grade material are considerably less.

Except for patches of lower Jurassic sediments, rocks on the west flank of the range are composed of regionally metamorphosed limestones, shales, dolomites, and minor conglomerates of Upper Triassic age. These are believed to have been laid down in a shallow, restricted, easterly embayment of the late Triassic sea. Near the close of the period the sediments were intruded by andesitic dikes accompanied, perhaps, by some warping and normal faulting. This was followed early in the Jurassic by more intense folding and extensive thrusting, with the intrusion of granophyre dikes. Late in the Jurassic, or perhaps early in the Cretaceous, sill-like masses of granodiorite and related dikes were emplaced. These intrusions vary locally in composition from diorite to quartz monzonite, but most range from granite to quartz diorite. Tertiary time saw the intrusion of rhyolite dikes and extensive normal faulting, which continues into the present.

Structure: The trend of the granodiorite and major pre-granodiorite features, such as the axis of folding, the andesite and granophyre dikes, the prethrust faults and, in a general way, the magnesite zone, is to the northwest. Dips are mostly to the southwest. Later faults and dikes strike easterly and dip steeply to the south. The bedding dips moderately—less than 40° but occasionally steeper—to the north and west.

C. MARTIN is a Consulting Geologist and H. P. WILLARD is Works Manager, Western Div., Basic Incorporated.

Gathering samples at the end of a shift in the Betty O'Neal pit of Basic Incorporated at Gabbs, Nev. Drillhole cuttings are analyzed for lime and acid-insoluble material. All holes are surveyed before drilling. Analyses are then plotted, and the chemical contour map is prepared. Holes are spaced 6½ ft apart and drilled 12 ft deep by 3½-in. wagon drills.

blasted, this grid is staked out on the broken rock. With the map and the stakes of the grid in the field

sium silicate, screening helps considerably. Under these conditions, the lime content may also be re-

Two sets of joints are well developed. One strikes N 65° E and dips 80° to the south; the other strikes N 45° W and dips 60° to the southwest.

Alteration: The early pre-thrust faults have generally been completely recrystallized and have little surface expression. Where faults cut the dikes the solutions have altered the feldspars to clays, the extracted silica being combined elsewhere to form the white, powdery complex magnesium silicates. The magnesite is invariably dolomitic where traversed by faults or flexure zones.

Along the contact with the granodiorite the reaction with magnesia has produced forsterite, serpentine, and a host of other complex magnesium silicate minerals still to be investigated. Porcelaneous *bone* magnesite is ubiquitous in veins and botryoidal masses. Dolomite in veins is also common, as well as brucitic marble. Within pendants of the carbondate rocks in the granodiorite, large masses of magnesite have been converted to brucite, the magnesium hydroxide. The smaller granodiorite dikes have been converted to serpentine. On weathering, the brucite changes to hydromagnesite. Two extensive bodies of brucite have been mined.

Magnesite Deposits: The magnesite occurs as the crystalline magnesium carbonate within, and near the top of a 3000-ft section of thin-bedded, dark gray to black, fine-grained dolomite occupying the upper imbricated plate of a gently westward-dipping major thrust. Interlayered with the magnesite are horizons of dolomite and dolomitic magnesite, indistinguishable, megascopically, from the magnesite. The magnesite and dolomite, separately or together, appear to interfinger in places with the underlying dark, fine dolomite contrasting markedly with the latter in appearance.

The surface of the magnesite and interlayered dolomite often has a sugary texture and generally weathers to reddish brown or buff. The texture on a fresh break may be fine-grained, or even aphanitic, to coarse-grained or sandy. The color is white to very dark gray.

Bedding in the fine, dark dolomite is readily apparent. In the magnesite it is more obscure, but discernible enough in places to aid in revealing the structure. The magnesite and interlayered dolomite zone is about 400 ft thick. Pendants of magnesite within granodiorite may extend to 600 ft or more, but this may not be a measure of actual thickness.

For the most part the magnesite rests on the dark, fine dolomite, which may contain appreciable amounts of tremolite at the contact or just below it. (Occasional tremolitic beds are also found lower in the section.) Although there are many fault contacts, displacements are rarely more than 20 ft. However, in areas where interfingering dolomite and magnesite have been imbricated by thrusting, several periods of subsequent faulting may make the structure unusually complex.

The age of the magnesite is thought to be Upper Triassic, as it is traversed by the late Triassic dikes and is involved in the early Jurassic thrusting. It may have originated in a sedimentary environment rich in sulfates. The source of the magnesia may have been disintegrating dolomite or some basic igneous rock. Removal of the lime as gypsum would permit the concentration of magnesia to build up later to be deposited as the hydrous carbonate, nesquehonite. Under moderate pressure, due perhaps to sedimentary loading, the hydrous carbonate would be converted to magnesite, much as gypsum is changed to anhydrite. Some support is given this view by the presence of a small gypsum deposit three miles north of Gabbs in interbedded Upper Triassic limestone and dolomite and by larger deposits of the same age elsewhere in western Nevada. Some of the hydrothermal and replacement effects observed along the margins of the magnesite may have been produced during dehydration and recrystallization.

Exploration: Initially, the high magnesite areas were outlined using a jolly balance or heavy liquids by taking advantage of the difference in specific gravity (2.85 for dolomite and 3.02 for magnesite) between dolomite and magnesite. As the variable porosity of the material introduced considerable error, this was supplemented by chemical analysis and microscopic study. Diamond drillholes were spaced on a regular 25, 50, or 100-ft grid.

Mining: An open pit operation removes 2500 to 4000 tpd, using a 2½-yd Bucyrus-Erie diesel-powered shovel, three to six 15-ton Euclid quarry trucks, and four to five 3½-in. wagon drills.

Material is removed in 10-ft benches. Blastholes drilled 12 ft deep on a pattern 6½ ft square produce good fragmentation and even bottom, with a minimum of mixing. Secondary blasting is seldom necessary. Although 20-ft benches are at times practicable in the low grade areas of the brucite pits, 10-ft benches provide better control over quality and greater extraction of the higher grade material.

Quality Control: To meet the various product specifications, five different grades of magnesite are being mined. These must be carefully selected to close chemical tolerances. Principal contaminants are silica and lime, occasionally alumina and, rarely, phosphorus. Except for the structurally disturbed tremolitic and dike areas, the silica content in the better parts of the deposits is usually below 2 pct. Although the lime may drop below 0.5 pct, it is most often over 1 pct. Because of the complex geologic history of the deposit, both lime and silica contents may vary widely within a short distance.

A substantial amount of high lime material is being used, but principal efforts are being directed toward extracting greater amounts of better grades of material without undue increase in costs—that is, magnesite containing less than 2 pct silica and less than 2½ pct lime. Since even a few loads of dolomitic or high silica material can spoil a thousand tons of good magnesite, quality control in the pit is of continuing importance.

Because the poor ore is not readily distinguishable from the better grades, the chief means of maintaining quality is still chemical analysis. Cuttings from the wagon drillholes are analyzed for lime and for acid-insoluble material, which is usually more than 80 pct silica, Analytical work is simplified by considering the insoluble material equivalent to silica, and the error introduced is small. Analyses are plotted and contour lines are drawn through points of equal lime content. Contour intervals are chosen to correspond to the various grade limits. When the several grade intervals are represented by different colors, a second set of contours can be superimposed to show the distribution of the silica. Any particular grade of ore can then be selected by following the colored area representing the lime limits around to where it is bounded by contours representing the silica limits.

A rectangular 20-ft coordinate grid is next drawn on the chemical contour map. After a bench is

blasted, this grid is staked out on the broken rock. With the map and the stakes of the grid in the field as guides, the various ore boundaries are outlined by flags for the guidance of the shovel operator. This permits the mine superintendent to plan removal of the various blocks so that contamination of high grade material is kept at a minimum. He can also organize movement of equipment to the best advantage.

The attack on any one block will depend on the grade of material, its shape, its location within the block, and the difference in grade between it and the adjoining blocks. Some blending is also possible. Material that may be a little higher in lime but low in silica for a particular grade can be blended with some in which the lime is low and the silica too high. In this way ore is recovered that might otherwise go for waste. Plotting the lime and silica separately also affords greater opportunity to select areas that might be beneficiated by screening and helps increasingly to reveal the finer structures of the deposits.

As each bench is mined the geology is mapped in detail. Supplemented by the chemical contour maps and by information from the diamond drillholes, these data are the basis for more accurate estimation of recoverable ore for several benches ahead, or for about a year in advance of mining.

Beneficiation: While the direct shipping brucite was being mined, the lower grade material was stockpiled and later reworked by hand sorting. For several years the rejected material from these operations—as well as some from even lower grade dumps—has been treated in a heavy media separation plant. Research is in progress to see what can be done with the tailings from this plant, as well as with some off-grade magnesite ore in the pits.

Silica content of the magnesite can generally be reduced by screening out a small portion of the finer fraction after it has been crushed. A drop from 4 pct or more to less than 2 pct is often possible; a drop from 3½ pct to 2 pct is more general. Whether this can be done depends upon how the silica occurs. If it occurs as tremolite, little is accomplished by screening. If it occurs as the white, powdery magnesium silicate, screening helps considerably. Under these conditions, the lime content may also be reduced somewhat, generally about 0.5 pct, seldom as much as 1 pct.

Processing: In preparation of granular refractories, the ore is crushed to −½ in. After chromite, iron, or other ingredients are added, depending on the characteristics desired in the product, it is dry ground to −65 mesh and transported by air slides to Fuller blending tanks and then to pug mills, where water and binding materials are added. From there the mix goes to the briquette presses, through the drier, and into briquette storage bins. The briquettes are fed from these bins into an oil-fired rotary kiln in which the temperature of the material is raised to about 3100°F. After leaving the kiln the clinkered material passes through a Fuller cooler. It is then crushed, sized, and transported to storage bins to await shipment.

Magnesium oxide is made by calcining magnesite in a 14-hearth Herreshoff furnace of 22-ft diam.

Acknowledgments

The present investigations were undertaken several years ago in connection with the mining operations of Basic Incorporated, of Cleveland, which, during the war years, brought the magnesite deposits into large-scale production, and has presently the most extensive operation in the area.

Credit for the refinement of techniques making the application of quality control to mining operations more effective goes in large measure to the mining department of Basic Incorporated at Gabbs, and in particular to A. M. Dixon, Mine Superintendent; T. M. Cahill, Assistant Mine Superintendent; and W. P. Smith, Pit Foreman.

References

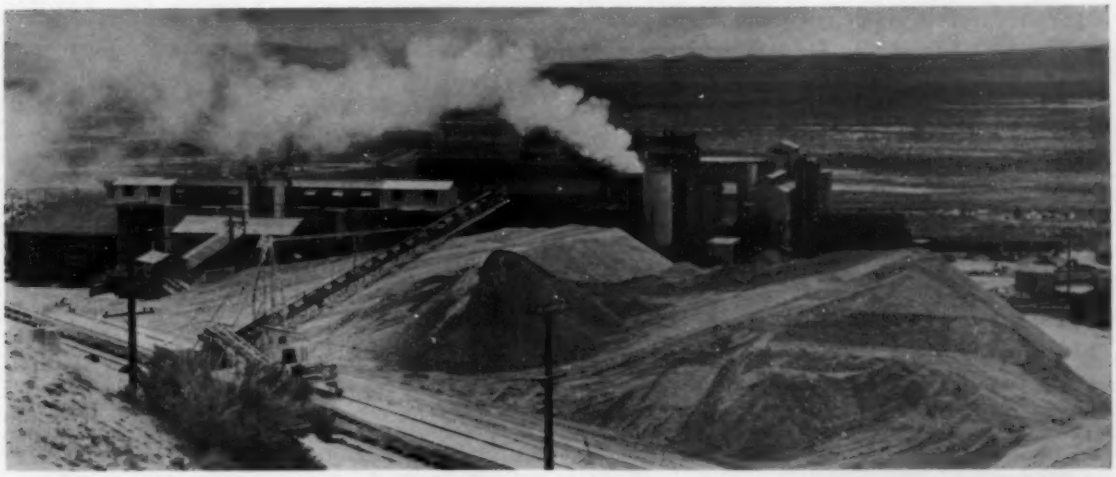
E. Callaghan: Brucite Deposit, Paradise Range, Nevada. A Preliminary Report. University of Nevada *Bulletin*, 1933, vol. 27, no. 1, 34 pp.

E. Callaghan and C. J. Vitaliano: Magnesite and Brucite Deposits at Gabbs, Nye County, Nevada. Unpublished report and map, 1948.

S. W. Muller and H. G. Ferguson: Mesozoic Stratigraphy of the Hawthorne and Tonopah Quadrangles, Nevada. Geological Society of America *Bull.*, 1939, vol. 50, no. 10, pp. 1573-1624.

S. W. Muller and H. G. Ferguson: Structural Geology of the Hawthorne and Tonopah Quadrangles, Nevada. *USGS Prof. Paper* 216, 1949, 55 pp.

E. Callaghan: Pre-granodiorite dikes in Granodiorite, Paradise Range, Nevada. *Trans.* American Geophysicists Union, 16th Annual Meeting, part 1, pp. 302-207. National Research Council, 1955.



Basic's rotary kiln and plant buildings. In the foreground are stacker and raw ore stockpiles. The view is towards the west across Gabbs Valley.

Successful adaptation of tungsten carbide to ro-

A New Look at Mining

by E. R. Borcherdt

RECENT years have seen great progress in drilling practices. The partial change from heavy drills and stopers to lightweight airleg machines has had great impact on stoping and drifting methods. The change was sparked, of course, when the Germans applied tungsten carbide to drill bits during World War II. This invention made it possible to drill nearly cylindrical blastholes, with a very minimum of drill steel changes, so that small fast-cutting bits* could be used without sacrifice of powder-loading density at the bottom of the hole. This is one of the few instances of increased efficiency through reduction in size. Usually the opposite is true.

* Starter sizes: 1⅝ in. and 1¼ in.

Application of these lightweight drills and small bits has lessened the vibratory stresses set up in the drill steel rod, and rod breakage has been greatly reduced. During the past several years phenomenal reduction in drill steel breakage has resulted from the use of carburized rods. These rods are now supplied by several manufacturers, with carburization of both the exterior and interior surfaces of the hollow drill steel. The rods are heat-treated over their entire length after the completion of bit connections, collars, or lugs (in the case of ⅞ Hex and round steel). This eliminates breakage from the usual metallurgical notch existing in conventional rods—there are instances of more than 2000 ft of drilling in hard ground before breakage. Steel rod failure results from fatigue checks, at right angles to the rod axis, progressing to a point where parting or breaking of the rod occurs. There are many of these checks in a used rod. Only the most advanced check causes the break, but with a small additional amount of drilling another check advances to the breakage point, and most of the value of reconditioning is lost. Since the development of carburized rods, the practice of discarding drill rods after the first break may be economically justified.

Chief hazards of using tungsten carbide insert bits are abuse, pilfering, and loss. In hard, dense rocks the bit wears to a reverse taper. With continued drilling this causes binding in the hole, and since carbide has very low shear strength, the inserts are fractured and ripped out.

E. R. BORCHERDT is Director of Mining Research, The Anaconda Co., Butte, Mont.

Pilfering and loss of the high-priced bits are problems most difficult to control. As a result of this situation one manufacturer has designed, perfected, and applied for patent on a single-use carbide bit, which has successfully overcome or greatly minimized these hazards. This has been accomplished by reducing the height of the insert to a critical dimension too small to permit formation of a reverse taper sufficient to cause binding of the bit in the hole. It is thus possible to use the bit to destruction without resharpening. In some cases its footage before discard compares favorably with footage obtained from a multi-use carbide bit with a number of resharpenings.

With tungsten carbide it is also possible to use large percussion drills in deep hole drilling. Here the drill follows the bit down the hole to eliminate losses in effective impact which is normally absorbed by the long string of drill rods and couplings required when the drill is mounted on the surface.

An American manufacturer has recently introduced mounted electric hydraulic pumps. These machines employ hollow drill steel and a spade-type carbide bit of 1⅜ to 1⅝-in. diam. They have drilled as much as 22 fpm in marble, limestone, soft sandstone, and certain types of copper, lead, and iron ores.

Some experimental work is being done in this country with a combination rotary and percussive drill manufactured in Germany, but until a material harder than tungsten carbide is available, it is doubtful that the drill will be applicable in igneous rocks. Its use now is confined to drilling sedimentaries and soft ores.

Longhole stope drilling continues to replace more expensive methods. Percussion drills and carbide bits are widely used, even at Anglo-American Mines in Rhodesia, where diamond bits would normally be favored. The following is the range of extension steel with threaded couplings that are available, together with recommended sizes of rock drills and bits to be used with them:

Hexagon Steel Size, In.	Couplings Size, O.D., In.	Bit Size, In.	Rock Drill Piston Size, In.
⅞	1 7/16	1⅝	3 or smaller
1	1 25/32	2 or larger	4 or smaller
1½	2¼	2¼ or larger	4-in. drill
1⅞	—	4, 4½, or 5	5½-in. drill

Successful adaptation of tungsten carbide to rotary drilling with tricone bits has made it possible to drill large blastholes in very hard taconites; using mud circulation, a Joy 250 rotary with 6-in. tricone bits recently drilled exploration holes 2100 ft deep.

Many improvements in jumbo design continue to appear. Most of the large jumbos are self-propelled, with hydraulic positioning so that each miner usually mans two drills. In Sweden a Hyster lift truck of 15,000-lb capacity is used for a drill jumbo. Although tunnel contractors in this country continue to use jumbos and large mounted drifters, the practicability of airleg drills in large tunnels has been demonstrated at Kittimat, and in Sweden, where nearly all tunnel work is done with airleg drills on platform jumbos. The world record for drifting with airleg drills was established last year, when Doornfontein Gold Mining Co. in South Africa advanced a 9x9 haulage drift in hard rock 1903 ft in 26 days.

In stoping, full advantage can be taken of the light weight and portability of this drill, and of its comparative longhole drilling reach with the telescopic feed leg. In Butte a new timberless cut-and-fill stoping method relies on the airleg drill, achieving excellent breaking with small diameter holes up to 14 ft long charged with ⅞-in. diam powder. Millisecond electric detonators helped in attaining good fragmentation, and dynamite strength was reduced from a No. 2 Gelex to a No. 5 Gelex, which is a little stronger than a permissible powder used in coal mining. In this case the usual tamping of powder with a loading stick is dispensed with. Loading is done by inserting a 16-in. stick of powder in the collar of the hole and pushing it toward the bottom with the next stick used. In this way powder is distributed uniformly from the bottom of the hole to the collar, eliminating the need for spacers. Increasing dynamite stick length to 24 in. has greatly reduced loading time, but there is room for improvement in the present time-consuming practice of hand loading. The pneumatic loading equipment used in Sweden, and that provided by one manufacturer in this country, have had only limited acceptance, probably because they have not been endorsed by the powder manufacturers.

Millisecond electric delay detonators continue to improve in quality and uniformity, and use of ignitor cord improves delay timing with cap and fuse blasting. Both these blasting facilities are finding increased application.

Many of the copper and iron open pit operations are experimenting with ammonium nitrate fertilizer as a substitute for bag powder or other free running explosives. Excellent results have been obtained with prilled ammonium nitrate nodules, which are coated with diatomaceous earth for improved moisture resistance or with natural ammonium nitrate to which diesel oil is added at the time of loading. This mixture is detonated by a comparatively small amount of dynamite. Difference in cost between bag powders and fertilizer have brought about large savings. Some results are not yet completely understood and will require further time for experimentation and evaluation.

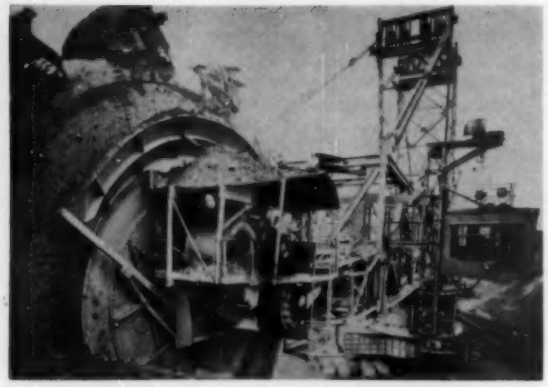
Secondary drilling in open pits is now done with mounted or unmounted drills attached to a self-propelled portable compressor, thereby eliminating the need for maintaining miles of airlines that are exposed to blasting hazards.

Loading: New methods and equipment for loading, both on surface and underground, are constantly being devised in an effort to perform the job more cheaply and quickly. In open pit coal operations tremendous shovels with 60-yd dippers have recently been introduced, and some open pit dump trucks of 90-ton capacity have appeared. (An article on German bucket wheel excavators and belt conveyors appeared in MINING ENGINEERING, December 1956.) In a German brown coal mine near Cologne a very large bucket wheel excavator is capable of loading 100,000 cu m per day into 100-cu m cars. This machine weighs 5600 tons, yet it is readily moved on caterpillar tracks. The 51-ft diam digging wheel has ten buckets of about 5-yd capacity. In a brown coal pit in Schwandorf, Bavaria, a somewhat smaller model is employed in a 100-pct conveyor operation. Both stripped material and coal are conveyed on the same belts at a speed of 4 m per sec, or 800 fpm. Stacker belts are run at almost 1600 fpm to project the waste material as far as possible beyond the end of the belt. So far as known, this is the first completely conveyorized pit operation in existence.

Robins Conveyors Ltd. of Johannesburg, a subsidiary of Hewitt-Robins Inc. of Stamford, Conn., has been awarded a $900,000 contract to furnish a conveyor system 8000 ft long and 54 in. wide to the Nchanga Consolidated Copper Mines in Northern Rhodesia. Gathering is done with 42-in. conveyors. The conveyor system will carry clay and soil that will be stripped from the surface of the open pit mine to provide access to underlying copper ore. Material will be removed by two bucket wheel excavators that will cut benches at 86-ft intervals in the large pit. The belts will travel at 800 fpm, about twice the

THE free interchange of information among mining companies throughout the world is one of the most important factors in the rapid development taking place in equipment and methods today. Development of new ideas in the mining industry, as in any other, requires imagination, common sense, and active interest in progress. One of the most effective methods, and the most productive of sound ideas, is to visit mining operations in other places in the world, to see what others are doing to improve on their ideas, and to come up with better ideas if that is possible.

A Caterpillar-mounted 630 Eimco loader equipped with a 32-cu ft bucket.



German wheel excavator capable of loading 100,000 cu m of material per day.

normal U. S. operating speed, and will move about 50,000 cu yd per day. The conveyors are paralleled with standard railroad track, so that it is possible to use one of the large German track shifters to shift the belts when necessary.

Considerable clay was encountered which proved difficult to handle with the large electric shovels, but no trouble of this kind is anticipated with the wheel excavators.

Engineers in South Africa have stated that this project will be the largest earth moving operation ever undertaken in Africa. It is expected that a mountain of waste containing 100 million cu yd will be accumulated in seven years of stripping.

Had this orebody been mined by underground methods it would have required 2000 workers, as contrasted with 600 workers needed for the open pit operation. Capital outlay for underground mining would have entailed an additional large sum for development.

Similar wheel excavators are at work in diamondiferous gravels in Central and South Africa.

Several underground Rhodesian copper mines have recently installed 25-ton side dump ore cars, dumped by an electrically operated overhead lift. Cars of similar capacity were observed in a large Swedish iron mine.

Some African mines were operating both man and ore car trains at speeds up to 35 mph. Ninety-pound rails were used and track installation was of very high quality.

A very large train loader, similar to the Boliden or Pierce loader developed by San Francisco Chemical Co., has been designed with capacity to remove an entire 8 to 12-ft round in a tunnel section of 14x17 ft in one trip. A diesel-powered Eimco Model 105 loads 7 or 8 tons per min into the hopper at the forward end of a three-car unit. Muck is moved out of the hopper by a 78-in. Amsco scraper, which slides on the grizzly rails at the top of the cars. Minus 24-in. material drops into the cars, and any oversize rock is moved to the hoist end of the train. The scraper is pulled by a 50-hp electric double-drum scraper hoist, with remote control available at the hopper. This equipment is now in service in the main adit of Anaconda's new El Salvador mine.

A small diesel-powered overshot loader is being designed for small sublevel drifts where the diesel exhaust will not affect the ventilation.

Cleveland-Cliffs Iron Co. installed a number of Herald chain conveyors, operated by two 50-hp electric motors, which offer promise for moving caved ore from finger raises, or from scram drifts to cars, jobs normally done with scrapers.

A new trench-scraping practice for loading skip measuring pockets employs two 150-hp double-drum scraper hoists fitted with large narrow drums to prolong rope life. One hoist is located just behind a discharge raise at each end of the trench with two 72-in. scrapers between. Each scraper is attached by rope from the haul drum of one hoist and a rope from the return drum of the other hoist. In this way the ropes to each scraper come directly off the slusher drums without requiring a tail sheave.

A caterpillar-mounted 630 Eimco loader equipped with a 32-cu ft hopper was recently applied to a timberless cut-and-fill stope in Butte in an effort to obtain better cleanup than is possible with a double-drum scraper. All of the broken ore was recovered, as there was no trenching such as results from operation of a slusher. Consequently no cleaning up by hand mucking was needed. Tramming its load 50 ft to the chute, this loader moved 1 ton of ore per min. The chief problem, however, was excessive lost time involved in hoisting this large equipment from floor to floor through an oversize timbered raise. Time loss was so great that the production cycle could not be maintained at the same rate as in a scraper-operated stope. In an orebody where chutes can be suitably spaced, and where timbered raises would not be required, there may yet be an efficient application for this type of equipment. These experiments definitely showed that cat-mounted equipment can be operated on freshly placed hydraulic sand fill.

The 18HR2 Joy loader has a loading record of 800 tons of abrasive Kiruna iron ore per shift. The new 19HR3 machine, with anticipated capacity of 20 tons per min, should greatly exceed capacity of the older model. A new shuttle car for use in pitching seams of ore at Blind River moves a load of 12 tons up a grade of 35 pct.

A very large electric-drive combination waste grader, spreader, and track shifter manufactured by Orenstein Kopple Lubecker Machinenbau AG in Lubeck, Germany, was observed in Kolwezi, Belgian Congo. This machine cost approximately $1.5 million and replaced 150 men required on five low dumps where 1½ million tons of sand and soil were being dumped each month. Spreading and ploughing operations were also done to compact and stabilize the dump material prior to track shifting. Track shifting was done at 10 to 12 mph and involved bending the track to a position where it was straightened.

Support: The new methods of ground support were directly responsible for the success of timberless cut-and-fill stoping that replaced square sets in the Butte district. This type of stoping was attempted in the same mine almost 20 years ago but failed because no one appreciated the importance of the time element to *beat the weight*. The first two cuts above the sill could usually be completed, but delays in filling and the use of coarse waste rock as fill material caused movement and weight in the hanging wall—to such an extent that heavy timbering and some bulk-heading were needed from that point on. With ineffective support the upward movement in the hanging wall is very rapid, and unless this movement is carefully controlled by fast removal of core and rapid hydraulic filling, timber

must be used. Rapid stoping of ore has been accomplished by using small diameter carbide bits and airleg drills followed by *immediate* rock bolting of the hanging wall so that the upward movement along this wall is not permitted to start.

Each year greater recognition is given to the value of hydraulic filling as a means of stope support and stabilization for large filled stope areas. Classification equipment is now available which will produce from most mill tailings suitable hydraulic fill material that is safe, readily permeable, and quick-draining. At the same time there is enough lubricating slime to minimize pipeline wear and to give the fill consolidation properties. When sand fill is properly dewatered, it consolidates and transfers weight to the walls. With other kinds of fill, weight is transmitted down through the stope fill to the sill supports.

Experiments were conducted during the year to reduce the amount of slime cleanup on sills by using flocculants and by increasing the percentage of solids in the fill slurry. It is expected that this high density slurry, 70 pct or more, will also reduce pipeline wear substantially. The best example of hydraulic filling practice, in the author's opinion, is at the Knob Hill mine at Republic, Wash., where solids in the slurry are maintained at 70 pct or more by means of a centriclone at the shaft collar. This material flowing from the fill line resembles sausage being extruded from a sausage machine.

A modern sand fill slurry plant was recently put into operation at Butte to serve several mines. With the installation of automatic density control it is hoped that a 70 pct slurry can be continually maintained.

Rock bolts as a means of eliminating timbering in drifts and crosscuts is most effective and of special value in warm mines where high ventilating air flows are required. Elimination of timber increases the air flow by reducing friction and at the same time permits a very substantial reduction in drift and crosscut sections. In waste drives this is particularly valuable.

The split, wedge-type bolt has been replaced to some degree by the expansion shell type, which can readily be retightened. With the expansion shell, depth of hole is not critical.

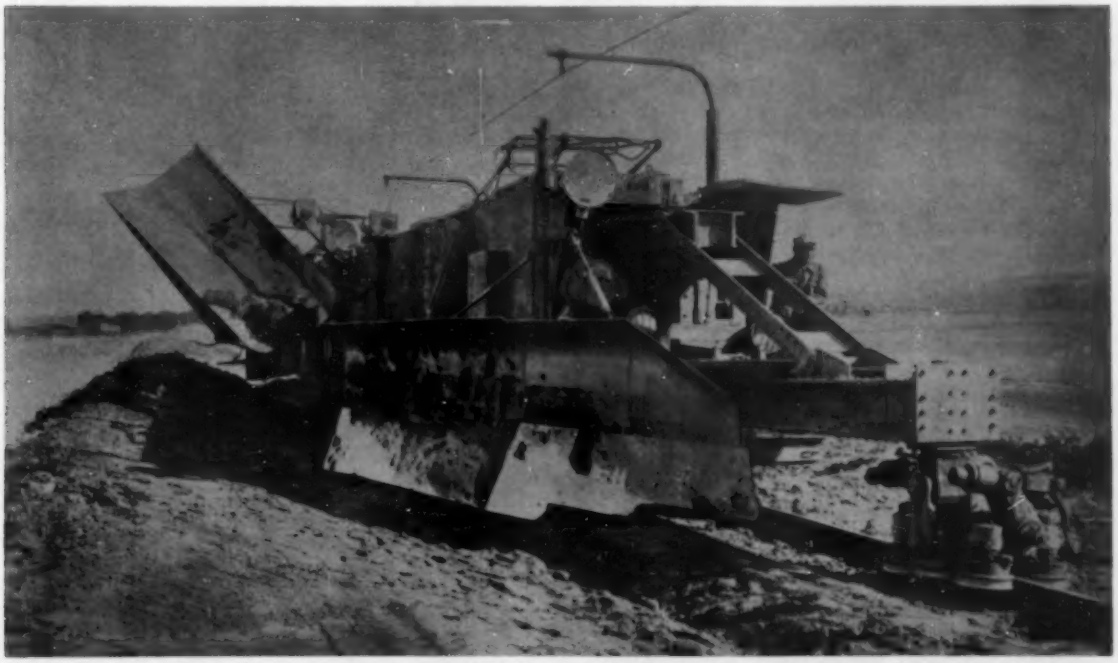
Another advance in rock bolting is the perforated steel sleeve that is filled with stiff grout and placed in the drillhole. A steel reinforcing bar or rock bolt is then driven into the hole, forcing the mortar through the perforations in the sleeve and filling solidly all the space between the sleeve and the surrounding rock. This gives large bearing and is useful in soft rock where conventional bolts slip or pull out. This idea was developed recently in Sweden.

Since the exhaustion of the government stock of used steel air field landing mats which were used with rock bolts, cyclone fencing has been substituted.

For support of heavy ground in block caving, concrete or yieldable steel sets are replacing timber, choice depending on conditions. An increase has been noted in the use of pneumatic placers as compared to pumpcrete equipment, but the pneumatic placers require an expert and conscientious crew for high quality concrete.

Hydraulic props or posts and yieldable steel cantilever posts, in general use in Europe, were being tried recently in several U. S. mines.

Timber is still required in the Butte district, and perhaps always will be, but the change from round framed sets to squared ones has substantially reduced timber handling costs by permitting steel strapping into standardized bundles. A modern framing mill was recently constructed at The Anaconda Co. saw mill operations at Bonner, Mont., where round stulls are cut to length and automatically slabbed on four sides before framing. This is



Large electric-drive combination waste grader, spreader, and track shifter manufactured in Germany and being used in Belgian Congo.

Incline Cryderman shaft mucker with square boom which keeps the clam bucket in a fixed position for easier handling by operator.

done at the rate of ten pieces per min. Timbers are then made up into unit loads in a mechanical stacker and steel strapped.

Shaft Sinking: Shaft sinking operations in South Africa are most impressive. Even before the advent of efficient mechanical mucking devices, record advances of more than 700 ft per month were made. Now the opinion of many South African engineers is that the practicable limit of advance with hand lashing or mucking has been reached and that henceforth this phase of the job will be limited to mechanical means.

In regard to shaft shapes, the consensus of opinion is that while the rectangular shaft is not entirely a thing of the past it will have application only under certain conditions, which are becoming increasingly rare. At least six elliptical shafts have been sunk in South Africa since 1945, but their popularity seems to have waned in favor of circular ones. Ample working room in the shaft bottom is a most important factor in high speed sinking, and in this respect the circular exceeds both rectangular and elliptical. When heavy pressures are encountered the circular shaft is in a class by itself. In the December 1948 *Transactions* of the Chemical Metallurgical and Mining Society of South Africa, J. T. MacIntyre and his colleagues say: "Consider a shaft with an area of inside lining of 500 square feet, which could be provided by (1.—) a circle 25′ —3″ in diameter, (2.—) an ellipse 36′ x 18′, (3.—) a rectangle 42′ x 12′. If a wall thickness of 1′6″ of un-reinforced concrete were adequate for the circular shape, then to give the same strength approximately a 10′ thickness would be required for the ellipse, and 22′ thick sidewalls and 7′ thick end walls for the rectangle."

There are, of course, some disadvantages in circular shafts, principally in the lower percentage of utilization possible, although in deep warm mines requiring large amounts of fresh air this objection is minimized.

Wide interest has been aroused in a novel sinking stage hoist developed by Robert Blair, consulting mechanical engineer for the Anglo-American Corp. of South Africa Ltd. This equipment utilizes two ropes, multiple sheaves, a double-drum friction hoist, compensating tower, and an automatic storage drum winder. It should materially increase the rate of circular shaft sinking.

With four sheaves each on the sinking stage and headframe, the weight of the Galloway stage is distributed over eight ropes at equal tension. Only one quarter of the weight is carried by the friction hoist, or about 20 tons. There are 3 2/3 wraps on the hoist, reducing the required tension on the other side to two tons. This tension is provided by suitable weights in the compensating tower.

Since the length of each of the two ropes required to sink a shaft 5000 ft would be 20,000 ft, it was not feasible to store the rope on the hoisting drum. Hence storage drums of smaller diameter were provided to take up or pay out the ropes. They are automatically controlled by the position of the weights in the compensating tower.

Each of the four pairs of ropes in the shaft acts as a guide for the four sinking buckets, thus doubling the usual capacity for muck removal from the shaft bottom. It is intended to use 8-ton kibbles instead of the 6-ton, which are the largest in use.

In connection with this development, a new design of mechanical grapple has been perfected to utilize more fully the potentialities of the Galloway stage and the Blair hoist. The grapple is suspended from the center of the bottom deck of the sinking stage on a jib that can swing in a full circle to pick up rock from any part of the shaft bottom. It is electrically controlled and its driving equipment is housed above the stage for protection from blasts. The grapple, jib, and operator's cage are constructed strongly enough to withstand blasting shock.

To operate the grapple, the operator must engage the clutch and release the brake; if he removes his hands from the controls, the grab stops automatically. Similar equipment was observed at the 25-ft diam West Dreifontein No. 5 shaft where 400 tons of muck were being disposed of in 3 hr using a 6-ton bucket.

Shuttering, or the placing of forms for concreting, is conducted from the middle deck. It is suspected that concrete transport by pipeline will be used instead of lowering it in a Blaw-Knox concrete bucket

as is the usual practice. It is believed possible to sink 1000 ft of circular shaft per month with this equipment, and since overhead is a large part of sinking costs the effect of high rates of advance providing a large divisor should result in phenomenally low sinking costs per foot.

North American shafts in general have been narrow and rectangular with a tendency in Canada to wide rectangular, approaching a square. A concrete-lined circular shaft 18 ft in diam was completed in August by the Dravo Co. for the Intermountain Chemical Co. at Green River, Wyo. Homestake Mining recently started a 19-ft diam circular ventilation shaft that will be sunk 5000 ft. The Hanna Co. has announced plans to sink a circular concrete-lined shaft 20 ft in diam at Iron River, Mich. At Carlsbad, N. M., two 15-ft circular concrete-lined shafts 1700 ft deep were completed last July. The maximum sinking rate at these latter shafts was 10 ft per day over a 30-day period. A Canadian subsidiary of the Potash Co. of America is sinking a large concrete-lined production shaft in Saskatchewan. Refrigeration is being used at a depth of 850 ft to stabilize the ground in certain water-bearing formations. In the Green River shaft the mucking was successfully done with a caterpillar-equipped 630 Eimco loader. Mucking equipment in use in both the U. S. and Canadian shafts has been the well known Riddell machine, the Boland device, which is similar to the Riddell, and more recently the Cryderman (MINING ENGINEERING, February 1957, p. 201). The Cryderman machine consists of an extensible boom attached on one end to the cage deck and on the other end to an air operated clam shell bucket. Directional controls are accomplished by seven operating air cylinders.

Until recently no successful means had been developed for the mechanical mucking of incline shafts, but last year the Cryderman vertical shaft mucker was adapted to use in a 55° incline shaft at the Page mine of ASARCO. Here a 5½-ft round in a shaft section of approximately 20 x 8½ ft requires about 2 hr to muck out in conjunction with a 45-cu ft skip for muck disposal.

Another interesting inclined shaft mucking operation is being conducted at Metaline Falls, Wash., by the Pend Oreille Mines and Metals Co. This 12° incline, 10 ft high and 18 ft wide, is being sunk with a 4-drill jumbo and a Model 630 Eimco mucking into a 10-ton open top skip. Advance for the first 1800 ft averaged 300 ft per month with two-shift operation.

Hoisting: Several large concrete towers to house Koepe hoists have been completed. One of these is a very large multiple Koepe installation at Kiruna, Sweden, which consists of eight skip units capable of hoisting more than 4000 tph. One of the largest Koepe hoists ever constructed is now being installed at the No. 5 West Driefontein shaft in South Africa. Two 2000-hp electric motors drive the Koepe sheave to lift a 14 to 16-ton skip 5460 ft. Four 1¾-in. ropes are used.

During the past few years concrete head frames have replaced steel frames in the larger Canadian installations. They are said to be materially cheaper and more rapidly constructed than steel frames. Only two or three are in existence in the U. S., but the increasing adoption of Koepe hoist should expand their use here.

Hoisting speed of the new San Manuel ore hoists, 3000 fpm, is believed to be the highest in the U. S. Africa, however, has a number of hoists operating at 3500 fpm. Men are frequently hoisted at the same speed, but it should be noted that these shafts are notably free from rough spots caused by subsidence and also that steel guides are used. Large four-deck cages with capacity of 68 men per deck enable one of the large Rhodesian mines to hoist or lower 2500 miners in one hour. Facilities for simultaneous two-deck loading and unloading are in use.

Bottom dump skips first used by U. S. mining companies are now in general use by Canadian and African mining companies.

At the Renstrom mine of the Boliden Co. in Sweden 200,000 tons of low grade zinc pyrite ore per year are hoisted automatically. This is perhaps the only installation of its kind where filling the measuring pockets as well as the skips is accomplished entirely by automatic controls so that no operating crew is required at the skip station. Underground crushing is applied to waste used for filling as well as to ore. The overall labor force both underground and on surface averages 85 men, giving an exceptional overall production of 12 tons per manshift in this cut-and-fill underground operation.

At Nkana a large semi-automatic underground hoist with ac drive instead of the usual dc drive is being installed. Cost of the ac hoist was substantially lower than its dc counterpart.

Miscellaneous: Observation of many installations of centrifugal air compressors in Africa, Europe, and Canada has convinced the writer that the many advantages they possess can be taken advantage of by U. S. mining companies, especially where 20,000-cu ft units or larger are indicated. Compared with reciprocating machines they are appreciably lower in installed cost per 1000 cfm, lower in cost of building space per 1000 cfm, lower in maintenance cost per 1000 cfm, and only slightly higher in power consumption per 1000 cfm. Machines observed were designed for 90 and 100 psi and were built in Switzerland and in Germany. Several American manufacturers are now building or designing them.

A very compact and efficient wet-type dust collector is of general interest. This unit is an original development by the Anaconda ventilation department in cooperation with Joy Mfg. Co. It will effectively remove dust particles of sizes down to one micron and below, with high retention characteristics. In Rhodesian mines concentrator equipment is being used to clarify underground mine water. The efficient removal of sludge has decreased wear on centrifugal pumps. In one mine sludge is put through an Oliver filter and the resulting product containing 6 pct copper is returned to the skip pocket. At other mines the liquid sludge, instead of being loaded into cars or skips for transfer to surface, is pumped from a collecting sump directly to surface by a Gardner-Denver high pressure mud pump commonly used in oil well drilling.

A high-strength, lightweight galvanized pipe designed for use with victaulic couplings is being investigated. Manufactured in Sweden, this pipe was observed in use in both Swedish iron mines and African copper mines. Since its weight is less than a third that of standard pipe, substantial savings are possible in price and cost of installation. Galvanized pipe has been standard for air and water lines in the Butte mines for many years.

Open Pit Loading Analysis For Better Cost Control

Here is a challenge! The author reaches startling conclusions when he studies the performance of boom shovels and tractor-excavators in open pit loading operations. His tools—standard costs and normal outputs—can be applied to other jobs.

by Paul-Emile Mercier

LOADING efficiency depends on cycle capacity of the loader, conditions of the mine, and mine organization. Cost of operation is the final criterion.

Two types of loaders are analyzed—the boom shovel and the tractor-excavator. Studies were made in an open pit at Kimberley, Nev., where shovels are the production units and the tractor-excavator is a clean-up loader. The report deals mainly with the analysis of cycle and output. Problems of pit organization are not acute. *(Other studies included in the original report and omitted here covered tractor-excavator application underground.)*

A statistical analysis compares the boom shovels among themselves and with the tractor-excavator. The influence of the material conditions and of the operator are charted and cannot be detailed in this summary. The Eimco 105 tractor-excavator is assigned to a clean-up job and its efficiency is therefore lower than for a shovel.

Setting aside the pit efficiency of loading proper in any particular mining operation, standard costs and normal outputs give the opportunity for a final comparison between boom shovel and tractor-excavator in their common field of applications.

It is the author's opinion that standard costs and normal outputs show that where both can be applied, the tractor-excavator (in this case an Eimco 105) is cheaper to operate than a boom shovel. The savings by using the Eimco 105 are more than 1¢, 2¢, and 3¢ per cu yd compared to 2½, 1½, and ¾-cu yd shovels, respectively. In surface mining of small or medium size, where blasting is good, the author feels that it is clear that the tractor-excavator as a production loader should be used in preference to a boom shovel.

LOW grade copper ore at Kimberley is mined today by open pit. The haulage fleet of 18 Euclid trucks of 15-cu yd capacity, rated at 24 tons, is backed up by bulldozer, scraper, and road-grader auxiliary units. Boom shovels are the principal loading units.

No data on costs of repairs and maintenance were available. Time studies were made, and considerable time was spent visiting with the mechanics in charge of repair work.

P.-E. MERCIER developed the material presented here as part of his Master's thesis for the graduate school of mining engineering at the University of Utah. Since completing this work he has returned to Belgium.

At Kimberley, where boom shovels and tractor excavator were assigned to different kinds of jobs, conditions were not favorable for comparisons. Generally speaking, digging at the property is not hard and no great variation of hardness of material was encountered. The material removed is altered and loose due to geological features and to previous underground mining.

Time Studies

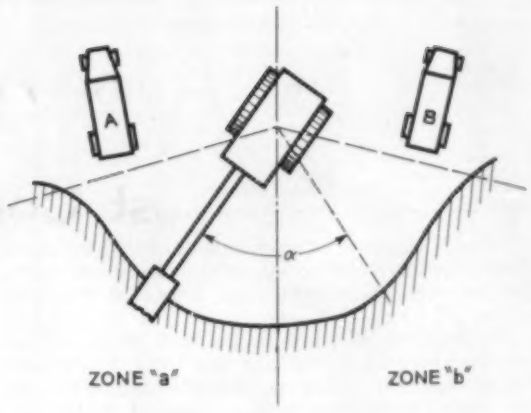
Analysis of the Cycle: Standard time sheets were constructed after initial observations. At first it seemed impossible to record digging time as well as the entire cycle time of a boom shovel because of the short periods involved. Finally, however, the probable range of times was tabulated in advance and the measures were recorded on a single strip in front of the adequate figure. In addition to the two scales of figures for recording the cycle and the digging times, the time sheet shows a third scale to record the last truck load cycle, which was noticed to be consistently longer than the other cycles.

The reason for this is easily understood. Assume that the shovel is loading truck *A*. The cycle starts when the bucket begins to dig inside the zone *a*. After digging, the shovel swings toward truck *A*, unloads the bucket, and swings back towards zone *a*. The cycle is completed when the bucket is in position to start digging for truck *B*. It then appears that the last cycle of a load takes longer because the boom must swing back into zone *b* to be ready for loading truck *B*. On the average the back swing is increased by an angle α.

For boom shovels, the times were taken from inside the cab of the operator. For the Eimco 105 this was impossible and times were recorded from the outside. Partly due to the cold and partly due to overlapping of the phases, digging time was not recorded for the Eimco 105.

Eight diagrams condense the results of the time studies. The first five diagrams are concerned with the cycle times of the different loaders.

Diagrams I and II compare, respectively, the cycle time and the digging time for different shovels. Diagram III attempts to relate the cycle time of the overhead loader to that of the boom shovel. Diagram IV gives the case of two observations in identical conditions. Diagram V shows the influence of the operator.



The last three diagrams analyze the number of cycles performed per truck load in functions of the conditions.

Diagram I—Cycle Time Frequency Curves: From a frequency table, the frequency distributions of three boom shovels are plotted in percentiles. Curves attempt to represent these distributions but do not fit perfectly. This is true particularly for shovels 202 and 203 due to the smaller number of measurements. Dispersion and skewness may be estimated by looking at the curves, but for the reason mentioned it is better to compute them directly from the frequency table.

Dispersion is measured by the standard deviation σ and skewness by the ratio α_3 of the third moment μ_3 over the cube of the standard deviation.

$$\sigma = \sqrt{\mu_2} \qquad \alpha_3 = \frac{\mu_3}{\sigma^3}$$

Both these items may be computed from the statistical moments of the second and third orders of the variable. For each case a transformation $x = X + hx'$ is chosen, providing a new variable x' for which the moments are easily computed. Then

$$\mu_2 = h^2 (\mu'_2 - \mu_1'^2)$$
$$\mu_3 = h^3 (\mu'_3 - 3\mu'_2 \mu_1 + 2\mu_1'^3).$$

In order to compare the costs in owning, operating and repairing boom shovels and tractor-excavator, a standard cost method should be set up. Consistent assumptions must be made whenever a generalized case is considered. The Second Technical Bulletin published in 1949 by the Power Crane & Shovel Association deals with the operating costs of diesel equipment, such as shovels, hoes, draglines, clamshells and cranes. At the end of this bulletin appears a cost estimating form which is most suitable for use in this analysis. The costs for the three different size shovels and for the tractor-excavator are computed using the setups proposed by the P.C.S.A. The cost calculations were computed using the recommended percentages for repairs, maintenance and supplies spread over the economic life of the machine. The costs include depreciation, interest, taxes, insurance, repairs, maintenance, supplies, engine, fuel and lubrication oil, direct labor of the operating crew, old age benefits, insurance, etc. The striking advantage of the Eimco 105 is due to lower original cost, smaller operating crew and, to a lesser extent, a lower consumption of fuel.

Loading Cost per Unit of Normal Output

Size Loader in Cu Yd	Cost per Hr, $	Normal Output in Cu Yd per Hr	Cost per Normal Cu Yd in ¢
¾ shovel	11.22	170	6.6
1½ shovel	16.82	300	5.6
2½ shovel	18.58	400	4.6
1½ Eimco 105	9.28	275	3.4

Table I. Loading Equipment

Company's Number	Type	Size, Cu Yd
204	electric	4½
203	electric	3½
202	Diesel	2½
205	Diesel	3
418	Tractor-Excavator	1½

Table II, opposite column, summarizes the results. Means, standard deviations, and measures of skewness are computed; modes are estimated from the graph.

The populations were limited to a 50 pct variation from the mean. Beyond this limit, times were not all recorded. It would be misleading to use the few times recorded in the calculation of the characteristics. These long and unusual times are interrupted cycles of . . . 35 . . . 50 . . . sec that occur for one of the following reasons: 1) a missed digging pass, not worth loading in the truck; 2) difficulty in opening or closing dipper; 3) truck not positioned for unloading; 4) operator talking to or delayed by oiler or pitman.

Shovel 203 is the fastest. Electric shovels are faster than diesel shovels and in this case the 203 is helped because a great proportion of the material is finely divided. Also positioning of trucks is good and swinging angles often approach 45°.

The counterpart of this fast operation is a larger skewness. Along a bench the conditions are not uniform and the faster the operator runs the shovel the greater the chance for widespread distribution.

Definitions of Terms

dispersion: The scatter or variability of the observations about some measure of central tendency.
Gaussian shape: Same shape as normal probability curve.
histogram: A graphic representation of a frequency distribution, consisting of a series of rectangles of width proportional to the width of the class interval and proportional in area to the quantities represented. Also called column diagram, block diagram, rectangular graph, etc.
mean deviation: A measure of dispersion obtained by taking the arithmetic mean of the absolute values of the deviations of the observations about a central tendency of the distribution. In a normal distribution the mean deviation is equal to 0.7979 σ. The mean deviation is often taken about the median because it is then a minimum. Also called average deviation.
mode: The value of the observation or measure that occurs the greatest number of times.
percentile: The point along the scale of a variable below which a given percentage of the observations fall.
population: The number of observations in any given statistical series or sample.

Table III. Characteristics of the Distributions

Type	Arithmetic Mean in Seconds	Mode in Seconds	Standard Deviation in Seconds	Measure of Skewness
Shovel 202	19.32	19	2.0	+0.49
Tractor-Excavator	18.02	18	3.40	+0.37

Table II. Characteristics of the Distributions

Shovel Tabulation	Arithmetic Mean in Seconds	Mode in Seconds	Standard Deviation in Seconds	Measure of Skewness
204 electric	18.80	18	2.43	+0.66
203 electric	17.92	16	2.40	+1.78
202 Diesel	19.32	19	2.01	+0.49

Although it is operated on the stockpile, shovel 202 (diesel) is somewhat slower than the two others. The operation is as uniform as the conditions.

Shovel 204, working under the toughest conditions, has the largest dispersion.

In conclusion, the characteristics of the different distributions vary as a function of the operator's skill, the material conditions, and the type of shovel. It is difficult to determine the extent of their individual influences when all of them are acting together. The only way to separate them is to run experiments, keeping all the factors constant but one. During the time studies, opportunity was afforded for doing this so far as the influence of the operator was concerned (Diagram V).

Diagram II—Digging Time Frequency Curves: Distributions of the digging time bring out the same basic differences as distributions of the cycle time. Relative positions of mode are identical. The cycle is primarily influenced by the digging time, but dispersion is larger for the cycle because its distribution is cushioned by the influence of the other phases, dumping and swinging, which are relatively constant for a standard location of trucks.

Thus the differences between the three shovels considered in the previous diagrams are more apparent. The means goes up in the following sequence: 203-204-202. The dispersion is large for shovels 204 and 203. Finally, skewness is least for shovel 202.

It is interesting to compare the two diesel shovels. Both display the same mode, but mean, dispersion, and skewness are larger for the 205 working on altered but unblasted material. This is exactly opposite to the condition for the 202 working on the stockpile.

Diagram III—Cycle Time Distribution of the Overhead Loader Compared With a Boom Shovel: As expected, the cycle time frequency distribution of the Eimco 105 differs from that of a shovel. Its distribution does not possess one single maximum, although a much larger number of measurements were taken for this loader than for any other shovel. Assuming the mode to be located at 18 sec, the frequencies present two other peaks—one at 15 sec and the other at 20 sec. As stated before, the main factor fixing the shovel cycle time is the digging time, the distribution of which has a Gaussian shape. For an operation with enough clearance on both sides of the shovel to allow uniform positioning of the trucks, swinging and dumping are almost constant factors. On the other hand, the cycle time of the 105—as watched at Kimberley—is not only controlled by the digging but also by the traveling. Traveling times depend on distance from truck to face. In ideal conditions, traveling should be kept constant and at a minimum, but the stockpile is low and the face recedes under the push of the bucket. Hence the distance run is increased appreciably in the process of loading a truck.

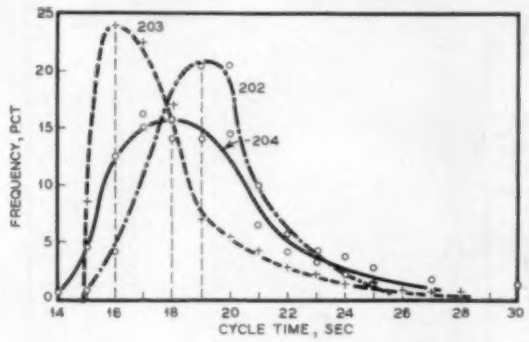


Diagram I—Diesel 202, 2½ cu yd, December 23, shift A. Electric 203, 3½ cu yd, December 31, shift A. Electric 204, 4½ cu yd, December 27, shift A.

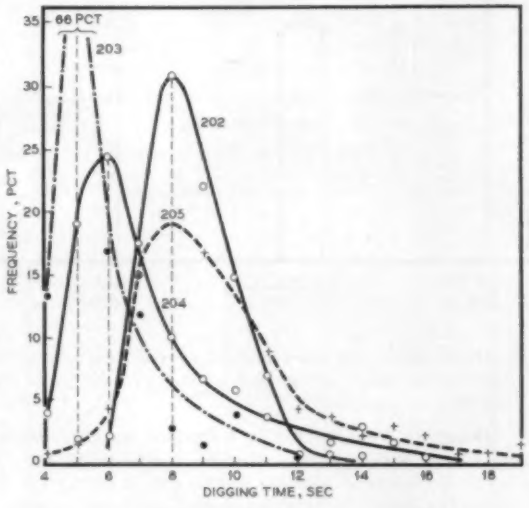


Diagram II—Diesel 202, ½ cu yd, December 22 and 23. Electric 203, 3½ cu yd, December 31. Electric 204, 4½ cu yd, December 27. Diesel 205, 3 cu yd, December 19.

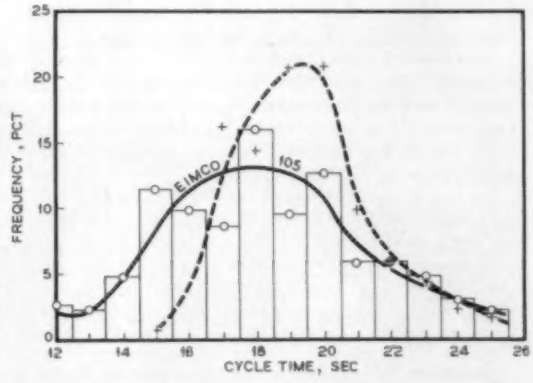


Diagram III—Eimco 105, 1½-cu yd diesel, December 28 and 30. Diesel 955, 2½ cu yd, December 23.

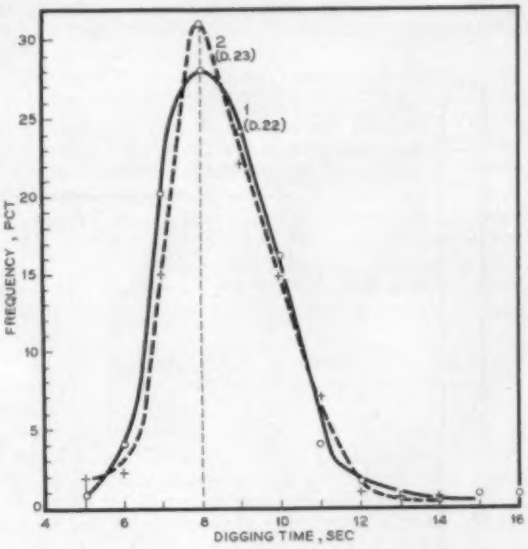


Diagram IV—Digging time frequency curves of diesel 202, 2½ cu yd, working in similar conditions, December 22 and 23.

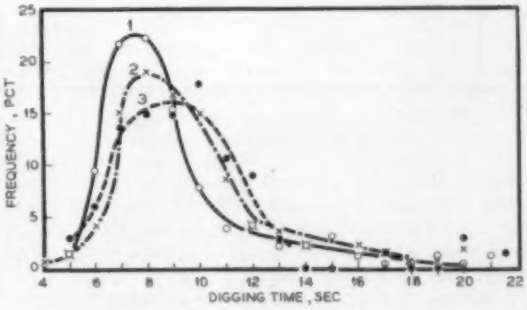


Diagram V—Influence of operator on cycle. Diesel 205, 3 cu yd. Operator 1, December 20, shift A. Operator 2, December 19, shift B. Operator 3, December 20, shift A.

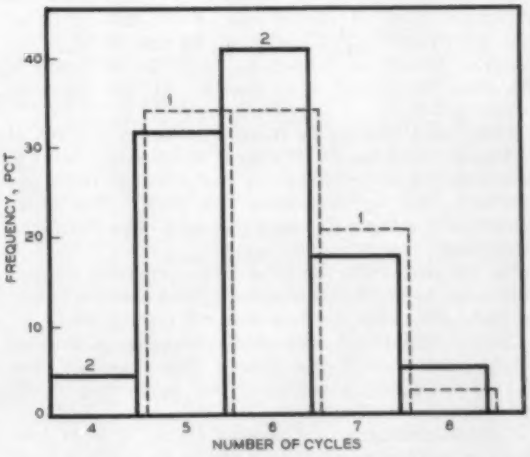


Diagram VI—Number of cycles per truck load with diesel 205, 3 cu yd, December 19 and 20.

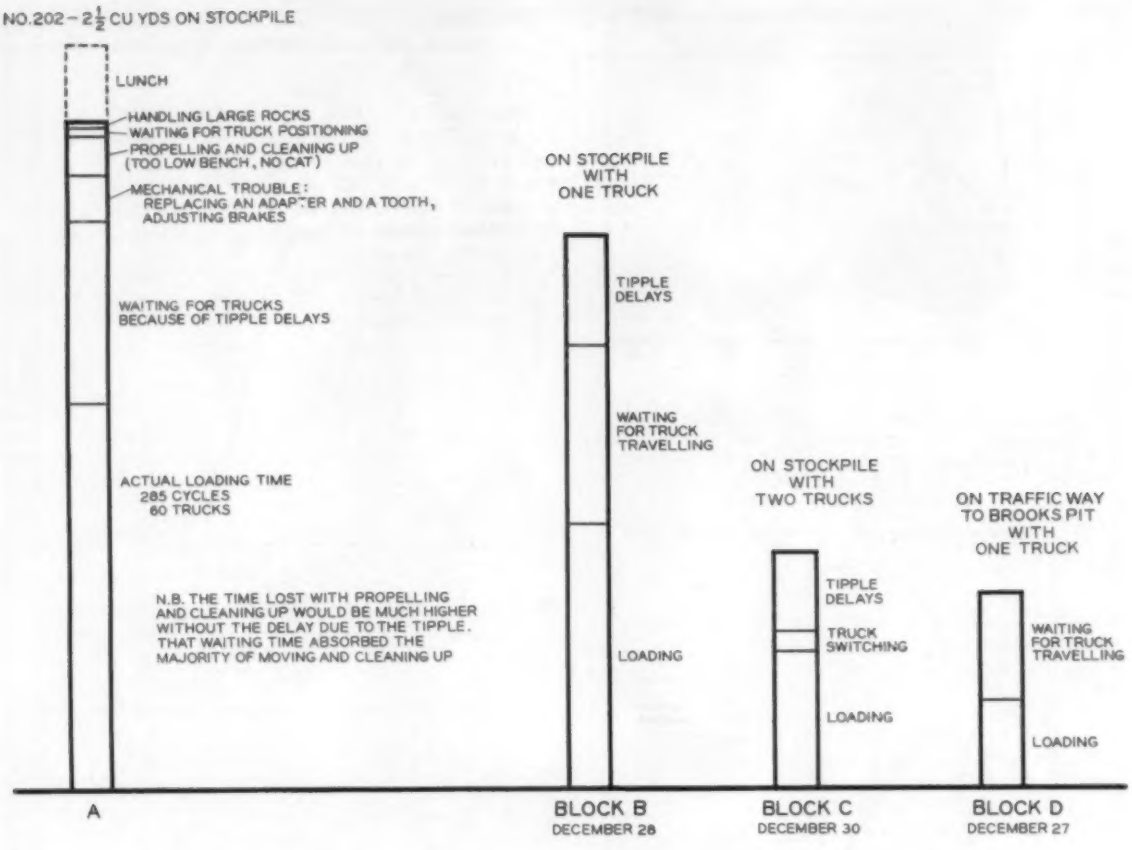

NO.202 – 2½ CU YDS ON STOCKPILE
LUNCH
HANDLING LARGE ROCKS
WAITING FOR TRUCK POSITIONING
PROPELLING AND CLEANING UP (TOO LOW BENCH, NO CAT)
MECHANICAL TROUBLE: REPLACING AN ADAPTER AND A TOOTH, ADJUSTING BRAKES
WAITING FOR TRUCKS BECAUSE OF TIPPLE DELAYS
ACTUAL LOADING TIME 285 CYCLES 60 TRUCKS
N.B. THE TIME LOST WITH PROPELLING AND CLEANING UP WOULD BE MUCH HIGHER WITHOUT THE DELAY DUE TO THE TIPPLE. THAT WAITING TIME ABSORBED THE MAJORITY OF MOVING AND CLEANING UP
A
ON STOCKPILE WITH ONE TRUCK
TIPPLE DELAYS
WAITING FOR TRUCK TRAVELLING
LOADING
BLOCK B
DECEMBER 28
ON STOCKPILE WITH TWO TRUCKS
TIPPLE DELAYS
TRUCK SWITCHING
LOADING
BLOCK C
DECEMBER 30
ON TRAFFIC WAY TO BROOKS PIT WITH ONE TRUCK
WAITING FOR TRUCK TRAVELLING
LOADING
BLOCK D
DECEMBER 27

Table III gives some frequency measures computed from the frequency table of the cycle time. The machines are of different types, but work on the same material, and this favors the comparison even though the operator's skill may vary.

Time distribution of the tractor-excavator is more dispersed for the reason explained. Skewness is low for both, as they work on the stockpile. As to the speed of the cycle, the tractor-excavator is faster; means and modes are lower. Frequencies of the cycle time below 18 sec are greater for the Eimco. Minimum times of 12, 13, and 14 sec result. These low values are not reached at all by any of the boom shovels. Better performances could be averaged if the stockpile height were greater and the material not receding.

Diagram IV—Digging Time Frequency Curves of a Shovel Working in Similar Conditions: A shovel was watched two consecutive day shifts on the same location. The operator was the same. The muck presented the same size and hardness. The following differences are detailed:

On December 22, the bank had a variable height, moderate on the left and passing to excessively low on the right. The operator was not feeling well.

On December 23, the bank presented a normal height and a uniform shape. The weather was stormy all through the shift but performance did not seem to be affected.

The distributions are almost equal. Curve 1 is slightly more dispersed; as a result its mode is lowered by 3 pct compared with curve 2; the actual frequency values of December 22 are not so regularly distributed.

Differences are too small to be considered significant; they may be related to the limitation of the number of samples.

Diagram V—Operator's Influence on Distribution of Cycle Times: Time studies were made for the same shovel on different shifts and working on the same material, namely, hard and unblasted waste.

Conclusions are obvious. The graph ranks the operators in the following order: operator 1, operator 2, operator 3. The mode, the mean average, the dispersion, and the skewness are progressively increasing when passing from the first to the second and from the second to the third. The difference of production between operator 1 and operator 3 is measured to be 30 pct of the best output.

Operator 1 runs the shovel faster, but he also runs it more smoothly; this has considerable effect on repairs and maintenance. Transmission, brakes, and cables suffer when controls are handled roughly. A hoist cable, for instance, may be broken much more frequently by abrupt operation.

Numbering the Cycles per Truck Load: Output depends not only on the average time of the cycle but also on the number of cycles performed per load.

Attention is paid to the discrepancy between the actual and the theoretical number of cycles, the latter being the ratio of the capacity of the truck to the capacity of the bucket.

Diagram VI—Influence of Operator on Number of Cycles Per Load: The operator has little bearing on the number of cycles per truck load. Both operators 1 and 3 fill a truck with the same average number of cycles. The theoretical number is one unit lower.

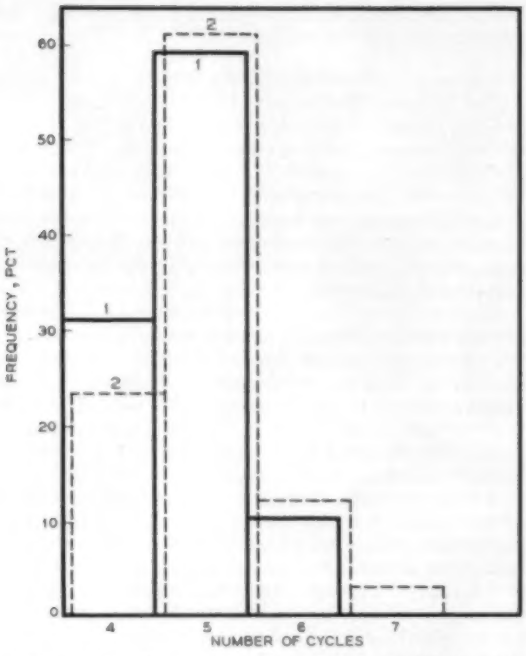


Diagram VII—Number of cycles per load for the 202 shovel.

Date	Histogram	Average Number of Cycles	Theoretical Number
Dec. 22	1	4.8	6
Dec. 23	2	4.75	6

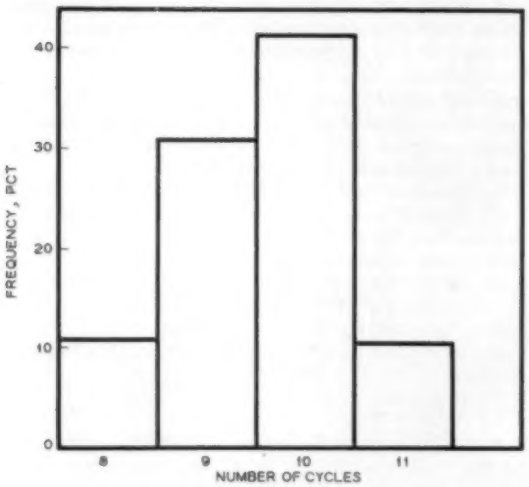


Diagram VIII—Eimco 105, December 28 and 30.

The shovel works in hard conditions. The bench is composed of altered but unblasted monzonite. The bucket is not filled for each pass.

Diagram VII—Histograms of the number of cycles per load for the 202 working under identical conditions: As the conditions are identical, there is no difference of behavior between the two observations.

The average number of cycles is more than one unit below the theoretical number. In Diagram VI the reverse was true. The reasons are that the shovel under Diagram VII works in the easy conditions of a stockpile while that under Diagram VI works along an unblasted bench. In the former case, the bucket is loaded beyond capacity and in the latter, below capacity.

The comparison between Diagrams VI and VII shows also a higher frequency peak for the latter. The operator working on fragmented material can perform more uniformly.

Diagram VIII—Number of Cycles Performed per Load by Eimco 105, December 28 and 30: To be consistent with what appears in Diagram VII, in which the 2½-yd shovel works the stockpile, the average number should again be lower than the theoretical number 10.

Actually, the average number of passes per load is 9.7, or very close to 10. An average between 8 and 9 was expected, particularly because of the favorable V shape of the lower blade of the bucket. This V shape should allow higher loads on the stockpile.

The operator may have an influence on the number of passes per load, but there was no opportunity to make comparisons.

Normal Production Rate: Normal production is computed from a normal cycle. The normal cycle is that of a loader operating with perfect regularity. The mode is chosen as the normal cycle in preference to any other average. The mode corresponding to the peak of the frequency curve is that value of the variable cycle time occurring most often.

Eimco 105

Normal cycle time: $C = 18$ sec (Diagram III).
Theoretical number of cycles per load: $n = 10$.
Normal waiting time for truck switching: $W = 30$ sec.

The time to load a truck consists of the time, W, waiting for the truck to switch; the time, D, dumping the first load; and the time, C, of running the nine other cycles. W is not entirely time spent waiting; it includes the first cycle except for dumping. Usually the time to load a truck is expressed by

$$T = W + D + (n-1)C. \qquad [1]$$

However, if the cycle takes longer than the switch, the formula reduces to

$$T = nC. \qquad [2]$$

Applying Eq. 1 to the case of the 105 at Kimberley and allowing 5 sec for dumping:

$$T = 3 \text{ min } 12 \text{ sec.}$$

Normal Output for Eimco 105

$$\frac{60}{3.28} \times 15 = 275 \text{ cu yd, or } 440 \text{ tph}$$

Diesel Shovel 202

Normal cycle time: $C = 19$ sec (Diagram I).
Last cycle: $C' = 24$ sec.
Theoretical number of cycles per load: $n = 6$.
The time to load a truck is given by

$$T = (n-1)C + C'$$
$$T = 2 \text{ min.} \qquad [3]$$

Normal Output for Diesel Shovel 202

$$\frac{60}{2} \times 15 = 450 \text{ cu yd, or } 720 \text{ tph}$$

Electric Shovel 204

Normal cycle time: $C = 18$ sec.
Last cycle: $C' = 25$ sec.
Theoretical number of cycles per load: $n = 3$.
The time to load a truck as given by Eq. 3:

$$T = 1 \text{ min.}$$

Normal Output for Electric Shovel 204

$$\frac{60}{1} \times 13.5 \quad 810 \text{ cu yd, or } 1300 \text{ tph}$$

Relating output to capacity of the bucket, the behavior of the three loaders is comparable. The tractor excavator and the boom shovels reach the same output of 290 tons per cu yd capacity per hr. This similarity is only apparent.

Actually, for the comparison to be valuable, the inevitable delays inherent in one type of loading must be taken into account. In the principle of the overhead loader, traveling is a phase of the cycle. With the progress of mucking, traveling changes continuously each time the truck driver chooses a position closer to the face. Moreover, the floor can be cleaned by the bucket as it moves forward towards the muck.

As for the shovel, the cycle is performed with the main body revolving. With the progress of mucking, the shovel must be moved to keep the dipper at the most favorable distance from the muck. A boom shovel is a heavy piece of equipment and propelling is slow; loading is interrupted during moving. The lower the bench, the more frequent the moves. Cleaning up is another task the shovel cannot perform easily. An auxiliary bulldozer is ordinarily used to remove rocks scattered on the floor. This interrupts the overall operation.

The time studies give an estimate of these delays for the particular cases. Prevailing conditions must be considered before attempts to generalize.

Diesel Shovel 202

Average time for propelling and cleaning up is 7 to 8 min per hr according to the time study of December 22, and 10 min according to the observations of December 23. With a conservative estimate of 8 min the normal output is

$$\frac{52}{2} \times 15 = 390 \text{ cu yd per hr, or} 625 \text{ tph.}$$

Electric Shovel 204

According to the time study of December 27, 5 min per hr is a good estimate to cover the time spent propelling and cleaning. Normal output then becomes

$$\frac{55}{1} \times 13.5 = 740 \text{ cu yd, or } 1190 \text{ tph.}$$

The difference between the recorded delays is explained by the fact that shovel 202 worked on a bench that was too low, whereas the 204 had the optimum height for its size.

Actual Operation Results

The Kimberley Copper Mine runs three shifts per day, seven days per week, so far as the shovels are concerned. There are three operating crews per shift for the four shovels. Ideally, each shovel would be idle or available one shift out of four for overhaul and maintenance. Actually, this depends on the circumstances of the breakages and on the policy of the company, which may plan different availability factors for its equipment.

Data in Table VI are computed from monthly records of the company. Two items are worth considering—time distribution and production. Columns V, VI, VII and VIII show the relative importance of the repairs and idleness (or availability) compared to the working time. Columns III and IV give data on production which will be related to the normals to qualify the efficiency of the different operations.

Availability and Repairs: The equipment is often available for work but is not needed. The time that it remains idle (column VII) diminishes step by step from the small to the large sizes. The Eimco, of 1½-cu yd capacity, remains available 65 pct of the time, the 2½-cu yd shovel 38 pct of the time, etc., while the 4½-cu yd shovel is idle only 6 pct of the total time.

In reverse order the hours worked (column V) increase from the small to the large size. An exception occurs with respect to the 203, due to the excessive repairs (columns VI and VIII).

Excluding the 203, an average ratio of the hours down to the hours worked is 25 pct (column VIII). In other words, a shovel is down 1 hr for every 3 hr of operation.

So far as can be determined by two weeks of observation, interruptions of operation were caused by repairs to the following, given roughly from the larger frequency to the smaller:

1) Hoist, crowd, haul-back, and trip cables.
2) Adapters, points, and bail for bucket; rebuilding and replacement.
3) Friction bands for brakes and clutches.
4) Hydraulic controls for drive and brake; mainly troubles were with the master cylinder.
5) Light plants on diesel shovels.
6) Internal shorts, power cables for electric shovels.
7) Injectors, governor on diesel engines.
8) Split in frames, booms, gears.

Cables can be replaced in 1½ or 2 hr. Troubles in the brakes, clutches, or controls stop the opera-

Table VI. Actual Performances—Average for the Last Months

I	II	III	IV	V	VI	VII	VIII	IX
Company Number	Type	Average Monthly Production (Tons)	Average Tph Worked	Hours Worked, Avg Pct of	Hours Down for Repair, Avg Pct of	Hours Idle, Avg Pct of	Ratio Hours Down to Hours Worked (Pct)	No. of Months for which Records are Available
204	4½-cu yd Electric	420,000	730	77.0	16.0	6.0	20.0	3
203	3½-cu yd Electric	215,000	540	58.0	30.0	12.0	50.0	5
205	3-cu yd Diesel	215,000	510	65.0	16.0	19.0	25.0	3
202	2½-cu yd Diesel	133,000	385	47.5	14.0	38.5	28.5	5
418	1½-cu yd Tractor-excavator	17,600	100	24.0	10.0	65.0	42.0	1*

* Two months for production averages.

Table IV. Comparison of Normal Production

Loader Size	Eimco 105, 1½ Cu Yd	202 Diesel 2½ Cu Yd	204 Electric 4½ Cu Yd
Tons per hour	440	625	1,190
Tons per hour per cubic yards	290	250	365

tion for half a shift. Motor troubles last at least a shift. Splits in the boom or in the setting gear interrupt the operation for several days. These estimates were made through a period of observation of two weeks.

With respect to the Eimco 105, Table VI does not give figures comparable with those obtained for the shovels. First, the averages computed refer only to one month for the 105 and are therefore not altogether reliable.

Secondly, the management does not use the Eimco 105 for quantity production, except in case of emergency. The loader runs only one shift per day (column VII) and on a few occasions may work 16 hr on ore to provide a cushion of production and to make up the daily quota if no shovels are available for carrying out that job.

The following are the kinds of jobs accomplished by the Eimco 105 during the writer's stay at Kimberley: 1) cleaning the tipple between the tracks and unloading directly into the cars (December 24); 2) cleaning and digging along trafficways leading to pit, widening them, or removing a slide (December 27); 3) loading ore from stockpile (December 28 to 30).

Thirdly, the repairs are not made under the same conditions. Special crews are assigned to the repair of the shovels. As soon as a breakage occurs, the shovel mechanics or electricians rush to the spot and try to minimize the delay. When the 105 breaks down, the operator drives it back to the garage and the repair is done by the garage mechanics when available. In other words, as there is no rush in production, there is no special rush in repairs.

Tonnage and Pit Efficiency: When data from column IV (Table VI) are compared with some normal outputs computed in Table IV, from the time studies, there are large discrepancies that need explanation.

The striking discrepancy between the pit efficiency reached by the Eimco and that reached by the shovels may be explained as follows:

Table V. Comparison of Actual and Normal Production

1	2 Actual Production in Tons per Hours Worked (Table VI)	3 Normal Production in Tons per Hours Worked (Table IV)	4 Ratio of 2 over 3 or Efficiency of Pit Operation
202 shovel	385	625	61.5 pct
204 shovel	750	1190	63.0 pct
Tractor-Excavator	100	440	23.0 pct

As stated in the previous paragraph, the 105 works on different kinds of jobs. These jobs could not be performed by a shovel. For example, on December 27th a trafficway leading to the bottom of the Brooks pit had to be widened. A shovel could not have accomplished that job without closing the haulage traffic, and moreover, a considerable length of time would have been spent to reach that particular spot. For the Eimco the work was easy. Maintenance of haulage was of primary importance. The length of traveling was sacrificed to satisfy haulage. This makes it clear that a straight cycle, as computed for fixing the normal production under the heading of Time Studies, could not be applied in many cases at Kimberley.

Another main reason for the discrepancy of pit efficiency between the shovels and the Eimco is that the latter is not kept busy by a sufficient number of trucks. The company takes great care of the haulage problem of the big shovels, which involve the highest investment. One truck out of 18 is left to the 105, however long the haulage. One unit more is assigned to it when a shovel breaks down and when the other shovels have more than enough trucks around them. That is not the usual case.

That policy has a tremendous bearing on the average output performed by the 105. The loader is waiting for trucks at least half of the hours worked and the waiting times are recorded as hours worked in the books. See evidence of the waiting time on the rectangular diagrams *B* and *D*. Case *C* represents the favorable case where two trucks are assigned to the 105 for a short haulage.

It now remains to explain why the pit efficiency of any loader is between 60 and 65 pct:

1) Any digging operation on the ore is slowed down because the tipple cannot keep pace (See rectangular diagrams *A*, *B*, and *C*). The cars are not removed fast enough to allow a smooth rate of dumping. The tipple is a bottleneck at regular intervals; the trucks have to line up nearby and the loader has to wait.

Several solutions may be advocated to speed up the switches:

a. A more powerful means of moving the cars may be used.
b. Fewer cars may be moved, but more often.
c. In the meanwhile, as soon as a maximum number of three trucks are waiting at the tipple, the next trucks arriving should dump on a nearby stockpile. Ore from the stockpile can be loaded fast and cheaply at a later opportunity when the fleet of shovels is not producing rapidly because of breakdown or lack of labor. The overhead loader could be sent on the spot to the stockpile and do a good job with the help of two hauling units.

2) Eight hours are not worked per shift. Discounts should be made for the midshift break of 30 min and for the delays at the beginning and end of the shift. These delays are longer for the Eimco, as there is no rush to produce and the operator takes more time for maintenance at the shop.

3) In their reports the operators and shifters underestimate the down-time hours. On December 20 the stoppages for a shovel were reported to have lasted 1 hr, while according to the time studies they amounted to 2 hr and 50 min. The reason was that in addition to hoist cable trouble the shovel was down for short but frequent light plant repairs which were not reported at all.

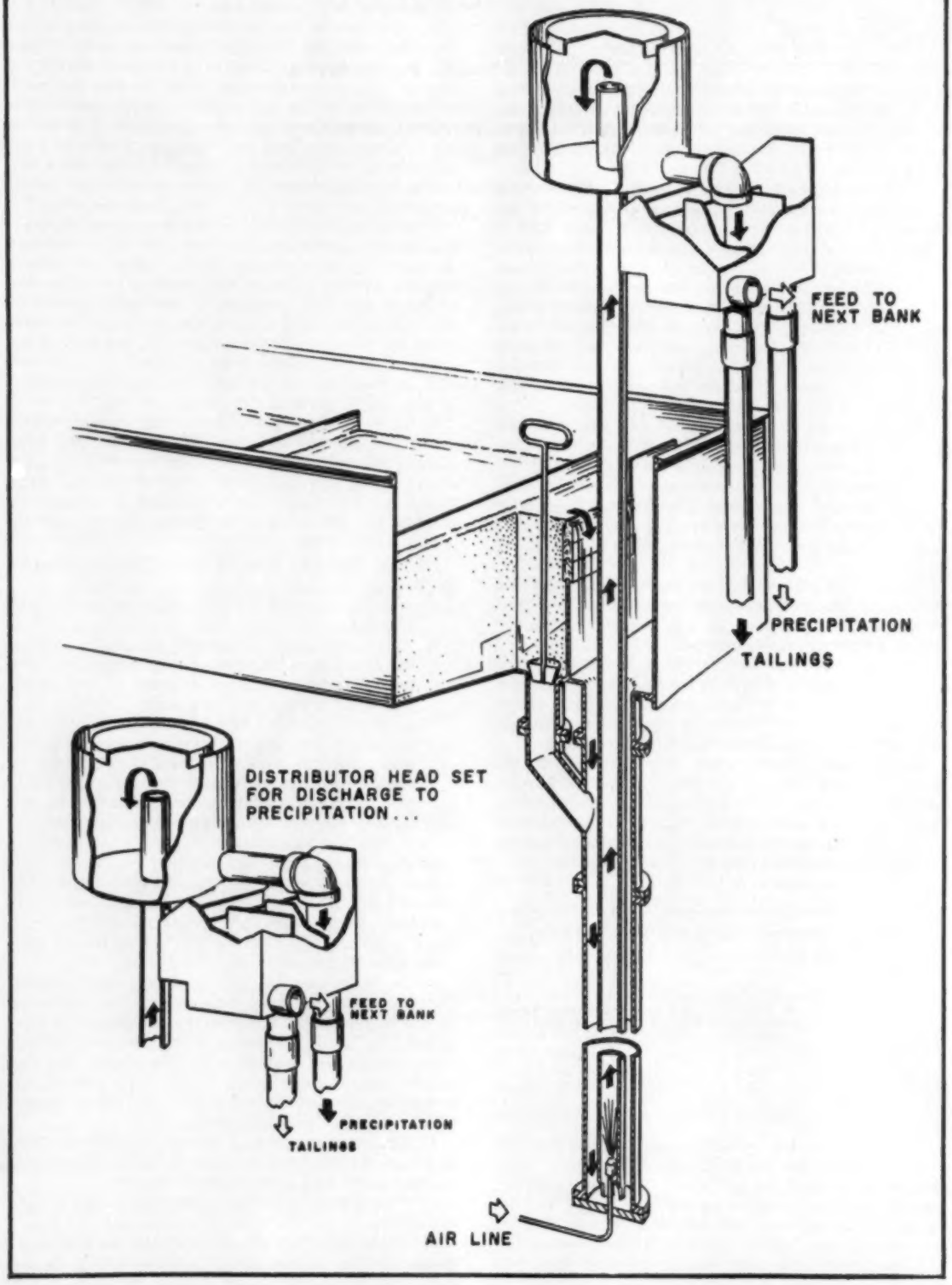
4) The operator usually leaves the control of the shovel to the oiler for an hour per shift. The oiler is an apprentice and production drops.

5) Miscellaneous delays reduce the working hour to 50 min.

6) Short time lags are often met when trucks are maneuvering. In an ideal operation they do not exist, but in practice they amount to 10 or 20 sec per truckload.

● **NORMAL OPERATION**

Overflow elevated to tailings...



The Resin-in-Pulp Method for Recovery of Uranium

by R. F. Hollis and C. K. McArthur

Five U. S. commercial uranium ore-processing plants now in final design or under construction incorporate this process. Dissolved uranium is recovered from acid-leached pulps by strong base anion exchange resins.

PRIOR to the application of anion exchange, all recovery of uranium from acid leach liquors precipitated an impure product requiring further upgrading before it could be refined. The ion exchange process, on the other hand, provides excellent selectivity for extracting soluble uranium from leach liquors, so that high grade concentrates can be produced directly. The discovery that uranium is readily adsorbed by anion exchange resins, together with the experience of resin and equipment manufacturers in water treatment, led to rapid development of ion exchange in a multiple column operation. Many processing plants using fixed bed ion exchange are in operation or under construction in Africa, Australia, and Canada. There are a limited number in the U. S.

Although the fixed bed process has been highly successful, the feed to the ion exchange columns must be a clear solution, which is obtained by filtration or by countercurrent decantation of leached pulps. With some ores, poor filtration or settling characteristics make production of a clear solution difficult. Most processing plants in the U. S. receive their ores from a number of small mines, and there is considerable variation in the settling and filtering behavior of the ores. An ion exchange process was therefore desirable in which the uranium could be recovered directly for the leached pulp by adding ion exchange resin, which could be then separated from the pulp by a screening operation. The process would thus resemble the cyanide-charcoal process in which gold is adsorbed from cyanide pulp by means of activated charcoal. Preliminary tests in which leached pulps were directly contacted with resin beads led to the development of the RIP process.

Process Chemistry: The ion exchange process for uranium recovery from sulfuric acid leach liquors depends on the high affinity of uranium sulfate complexes for the anion exchange resin. It has been demonstrated that the uranium is adsorbed primarily as the trisulfate complex $[UO_2(SO_4)_3]^{-4}$, and to a minor extent as the disulfate complex $[UO_2(SO_4)_2]^{-2}$. Appreciable amounts of sulfate and bisulfate ions are also adsorbed.

All other things equal, the adsorption of the disulfate complex is to be preferred, since it gives a higher uranium loading per unit amount of resin. In practice, however, it is not possible to adjust the feed composition in the required manner. The requirement for a high loading of disulfate complex is a high uranium to sulfate concentration ratio. Ores commonly found in the U. S. give leach solutions too low in uranium to meet this requirement.

It has also been found that uranium loadings increase with increasing pH. This follows from the fact that bisulfate has a greater affinity for strong base anion exchange resins than sulfate, so that fewer resin sites are available for uranium adsorption in acid solutions where equilibrium favors the bisulfate ion.

The composition of leach liquors obtained from domestic ores varies considerably in uranium and sulfuric acid concentration. Typical leach solutions are adjusted to pH 1.3 to 1.7 and contain 0.3 to 1 g U_3O_8 per liter and 10 to 20 g sulfate per liter prior to ion exchange treatment.

Recovery of uranium by ion exchange involves three basic operations:

1) Adsorption. The resin is contacted with the uranium-bearing solution, and the uranium is adsorbed. This operation is commonly referred to as the adsorption, loading, or exhaustion cycle. The reaction whereby the uranium is adsorbed by the resin may be written as follows. R indicates the resin:

$$4RNO_3 + [UO_2(SO_4)_3]^{-4} \rightleftarrows R_4UO_2(SO_4)_3 + 4NO_3^-$$

or

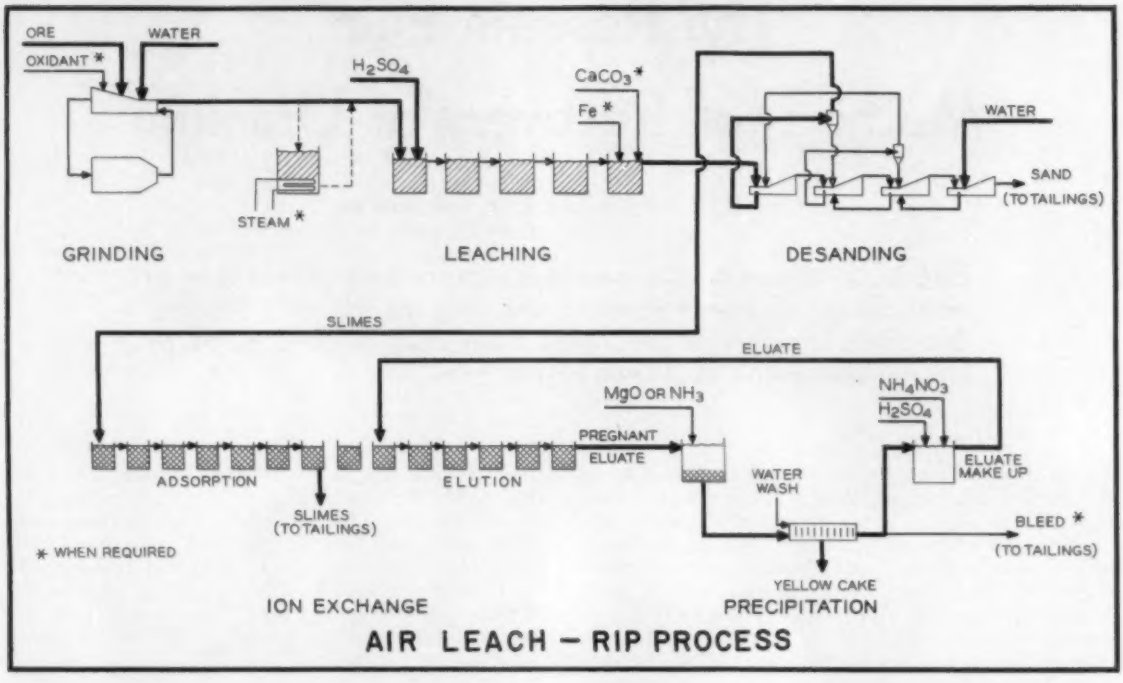
$$2RNO_3 + [UO_2(SO_4)_2]^{-2} \rightleftarrows R_2UO_2(SO_4)_2 + 2NO_3^-.$$

2) Elution. The adsorbed uranium is removed from the loaded or exhausted resin by contacting the resin with an acidified chloride or nitrate solution. This operation is referred to as the elution cycle. The solution used for elution is called the eluant and the resulting uranium-rich solution, the eluate. The elution reaction proceeds from right to left in the equations above.

3) Precipitation. The uranium is precipitated from the eluate by neutralization, and the barren filtrate is recycled for elution after adjustment of pH and nitrate concentration.

Process Variables: Adsorption by ion exchange is controlled by equilibria involving the concentration of the adsorbed uranium on the resin and the concentration of the adsorbable uranium in the solution. In a column system, the uranium concentration in the resin and in the solution decreases from top to bottom. Conditions are ideal for the necessary equilibria whereby simultaneous saturation of the resin and complete removal of the uranium from the

R. F. HOLLIS is with Uranium Reduction Co., Moab, Utah. C. K. McARTHUR is with the Raw Materials Development Pilot Plant of National Lead Co. Inc., Grand Junction, Colo.



AIR LEACH – RIP PROCESS

solution are attained. However, in a batch type of contact, adsorption occurs only to the point where there is an equilibrium between the uranium on the resin and in the solution, and no concentration gradient exists in the resin or solution. Thus to insure complete recovery of uranium, a number of individual stages, or contacts, are required, in each of which a fixed amount of uranium is adsorbed. Therefore, a fundamental difference between a column and a batch contact system is the number of stages available for adsorption. In a column, as in any packed tower, this number of stages is very large, whereas in a system of individual contacts, the number must of economic necessity be small.

Other points of difference are in the choice of operating variables. The variables in a column system are the solution retention time and the total throughput of solution per unit volume of resin. These same variables exist in a batch contact system, but in addition the ratio of solution to resin may be any desired value. In a fixed bed column system, the ratio of solution to resin is determined by the void volume in the resin bed, which is approximately 40 pct of the bed volume.

To evaluate the applicability of batch contact operations to uranium processing, laboratory experiments were performed on clear solutions. These experiments showed that the resin can attain the same degree of saturation by repeated batch contacts as is possible in columns. Likewise, by repeated contacts with fresh resin, a uranium-bearing solution can be as completely stripped of its uranium content as in column operation. Finally, by repeated contacts with a one-molar nitrate or chloride solution, a resin loaded with uranium can be completely stripped of its uranium content.

Further batch contact experiments showed that uranium is readily adsorbed directly from leached pulps by anion exchange resins and that the rate of uranium adsorption is essentially unaffected by the presence of ore solids.

However, no data were available on the effect of contact time, solution to resin ratio, and number of stages on uranium adsorption. Investigation of these variables was required before it was possible to go further in developing the RIP process.

The effect of extent of loading and contact time on uranium adsorption was studied in a series of tests in which 10 ml of resin was contacted with 250 ml of artificial leach liquor containing 0.14 g U_3O_8 per liter. Solution samples were taken periodically for assay, and after 2 hr the liquor was removed from the resin and 250 ml of fresh liquor added. This procedure was continued for ten 2-hr contacts, at which time the loading was 21 g U_3O_8 per liter of wet-settled resin. Fig. 1 plots data for contacts 1, 2, 4, and 10 showing the percent uranium adsorbed from the fresh solution as a function of the contact time. From these data, two main conclusions can be drawn. First, the time required to reach steady state is short; well over 50 pct of the uranium that can be adsorbed is picked up by the resin within the first 10 min of contact and steady state is reached in about 40 min. Second, the uranium loading on the resin has no apparent effect on the time required to reach steady state.

Tests were run to see how much difference there was in resin loading in a multiple contact batch adsorption system when 5-min and 15-min contacts were used instead of the 40-min contacts previously found necessary to attain steady state loading. In each test a 10-ml portion of resin was contacted with ten successive 250-ml portions of an artificial uranium solution. Fig. 2 presents the cumulative uranium loading on the resin vs the total contact time. The data show that loadings of 95 and 81 pct of the steady state value were obtained respectively with the 15-min contacts and the 5-min contacts. A suitable retention time would thus be 15 min; longer retention times are unnecessary.

In Fig. 3 the results of tests are presented in which several 1-liter portions of leach solution were con-

Table I. Effect of Solution Retention Time and Solution to Resin Ratio on Rate of Uranium Adsorption and Number of Stages Required

Solution Retention Time, Min	Solution to Resin Ratio	Stages Required	U_3O_8 Adsorption Rate, Mg U_3O_8 Per Ml Resin Per Min
4	2.4	6	0.104
4	5.1	7	0.328
4	10.2	9	0.548
15	4.0	5	0.102
7.5	4.0	6	0.170
4	4.0	7	0.273

Table II. Effect of Solution to Resin Ratio and Number of Contacts on the Eluate Grade

	Eluate, Grams U_3O_8/l			
	32-Min Contact at Ratios of			16-Min Contact at Ratio of
Contacts	1.4	2.8	5.6	5.6
1	6.58	5.75	3.32	2.74
2	5.95	2.70	0.93	1.29
3	2.51	1.45	0.24	0.50
4	1.65	0.27	0.06	0.21
5	0.65	0.11	0.02	0.04
6	0.50	0.05		0.01
7	0.20			
8	0.16			

Table III. Four-Stage Batch Countercurrent Elution Test

	Eluate, Grams U_3O_8/l	
Cycle	Stage 1	Stage 4
0	6.7	0.01
1	7.0	0.01
2	6.9	0.01
3	6.9	0.003

tacted for 2 hr with different amounts of resin. The data show that the time required to reach steady state was essentially unaffected by the ratio of solution to resin.

In the preceding experiments, the resin was contacted batchwise. In a commercial operation, the flow of solution would be continuous, whereas the resin in effect would be intermittently advanced countercurrently. By analogy to column operation, the resin in the first stage should reach saturation when the effluent from the last stage reaches a uranium concentration of about 2 pct of the feed concentration (cutoff). Data in Table I summarize the results of experiments simulating commercial operation in which the effect of solution to resin ratio and solution retention time were studied.

The data show that the number of stages required for saturation of the resin to occur simultaneously with cutoff increases as the solution to resin ratio increases and as the solution retention time decreases. At the same time, the quantity of uranium adsorbed per minute per milliliter of resin increases with increasing solution to resin ratios and decreasing solution retention time. Obviously, then, maximum resin utilization would be obtained by a large number of stages with high solution flow rates and solution to resin ratios.

Two factors will establish economic limits for solution to resin ratio and solution retention time. 1) As the number of stages increases, the size of the cell will decrease, but the capital cost will increase because it is generally cheaper to build a large cell than several small cells of the same total capacity or solution retention time. 2) After the resin has been loaded, it must be removed from the adsorption circuit and eluted. This requires time. Consequently, if loaded resin is being removed from the adsorption circuit faster than it can be eluted with a given volume of eluate, additional equipment and resin inventory are required.

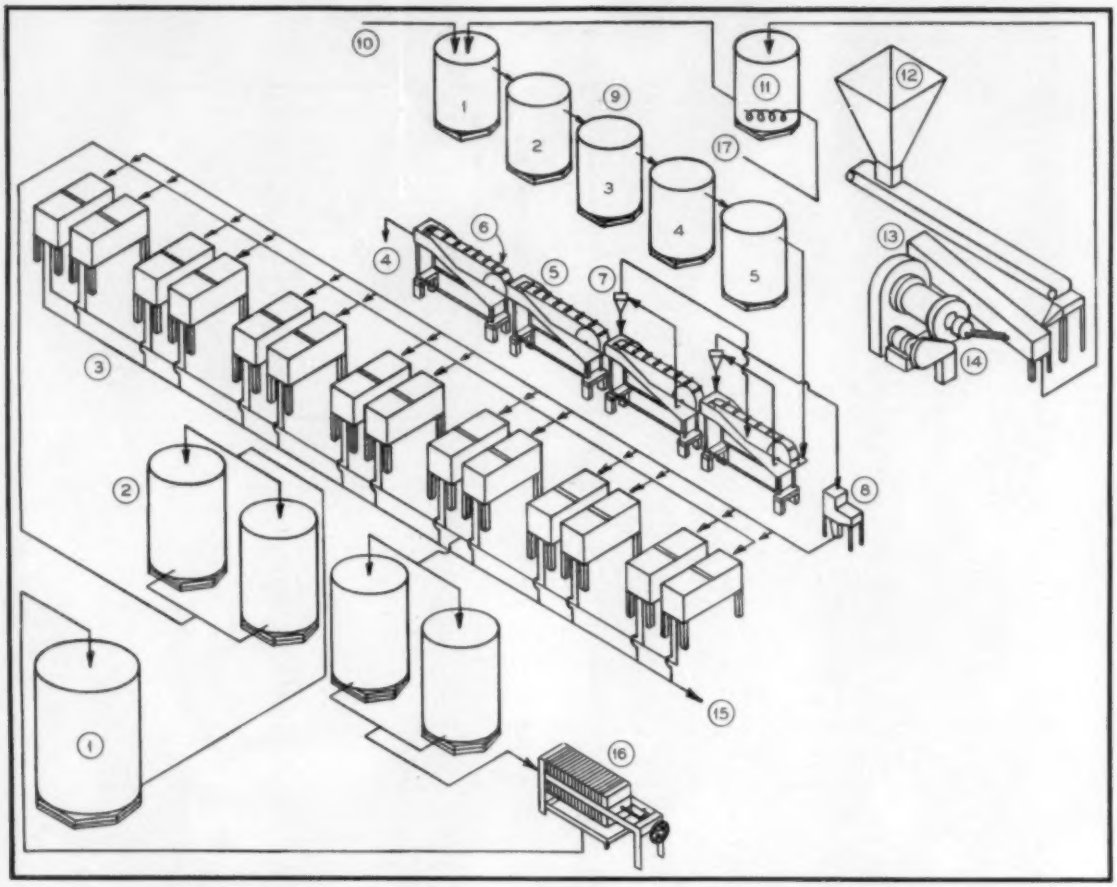
The elution of uranium from loaded resin proceeds because of the high concentration of adsorbable anion in the eluant and is subject to the same considerations that affect uranium adsorption. In uranium elution, two requirements must be met. First, the uranium must be completely removed from the resin to reduce uranium losses during the succeeding adsorption cycle. Second, the uranium should be contained in the smallest practical volume of solution to reduce subsequent precipitation costs.

Table II summarizes the results of batch contact tests to determine the effect of solution to resin ratio and contact time on the number of contacts required to obtain complete elution. Elution of uranium is usually considered completed when the concentration of uranium in the last fraction of the eluate does not exceed 0.1 g per liter. The eluant used in the batch contact tests was $0.9M$ $NH_4NO_3 - 0.1M$ HNO_3. From Table II it is evident that higher grade eluates are obtained if the solution to resin ratio is reduced. However, as the ratio becomes smaller, the number of stages required for complete elution increases.

Data in Table II were obtained from successive batch contacts with fresh eluant. Data in Table III present the results obtained from a batch countercurrent system in which fresh eluant was introduced only in the last stage of the elution circuit. The solution to resin ratio in these tests was 5.6 and the contact time was 32 min per stage.

Comparison of Tables II and III indicates that countercurrent movement of the eluant does not appreciably affect elution efficiency but does materially improve eluate grade. The actual data presented indicate a twofold increase in the U_3O_8 concentration of the eluate. Thus the cost of reagent for precipitation of uranium from the eluate would be almost halved. Further increases in the uranium concentration of the eluate may be obtained by increasing the number of stages.

Process Development: In the initial experiments leading to the development of the final RIP process, standard anion exchange resin beads were added to a leached pulp and later removed by screening or, alternately, the resin was placed in a stainless steel wire mesh basket which was gently agitated in the pulp. The fine size of the beads, predominately 20 to 48 mesh (0.30 to 0.83 mm), necessitated the use of screens having an opening no larger than 65 mesh (0.20 mm), and the transfer of the pulp through the screen was difficult. A program of resin development was undertaken in cooperation with commercial resin manufacturers to produce ion exchange resins in a form that could be readily separated from the pulp by a coarse screening operation. The resin forms developed were of two shapes: thin sheets and extruded 1/16-in. diam rods. A magnetic resin was also prepared by incorporating finely ground magnetite into the sheet or extruded forms. The adsorption characteristics and physical stability of these new resin forms proved to be generally unsatisfactory. Efforts of the resin manufacturers were then directed to the production of coarser bead resins having a predominately 10 to 20 mesh (0.83 to 1.65 mm), thus permitting a separation of resin from the pulp with a screen having a nominal 28 mesh (0.59 mm) opening. Early lots of these coarser bead resins had generally low chemical effi-



National Lead Co. Inc. acid resin-in-pulp pilot plant flowsheet using Hidden Splendor ore feed.

1-Storage tank.
2-Eluate make-up precipitation tanks.
3-RIP cells.
4-Tailing.
5-Drag classifiers.
6-Water.
7-Cyclones.
8-Screen and sump.
9-Leach tanks.
10-Acid feed.
11-Heat tank.
12-Fine ore bin.
13-Spiral classifier.
14-Ball mill.
15-Tailings.
16-Filter press.
17-Steam.

ciency and low physical stability. During the past two years, large bead resins have been improved so that today their chemical and physical stability is comparable to that of the standard bead resins.

With the successful production of coarse bead resins, the RIP process was an actuality. However, one more link in the chain was necessary—development of a mechanical method for conducting the basic adsorption and elution steps. This mechanical method would have the following requisites: :

1) Close metallurgical control.
2) Minimum resin loss (mechanical and attrition).
3) Constant control of resin to pulp and resin to eluant ratios throughout the system.
4) Applicability to type of resin beads available.
5) Low maintenance and operating costs.
6) Simplicity and flexibility of operation.
7) Low capital cost.
8) Capability of expansion from small units to larger plant scale models without sacrifice in efficiency.

It was recognized that all these requirements for good resin-in-pulp operation probably could not be incorporated in the first machine developed for an operating plant. It was apparent, however, that close metallurgical control, minimum resin loss, and control of resin to pulp ratios were absolutely essential and could not be sacrificed. These three basic requirements had more bearing on the selection or rejection of proposed machines than any other factors. It was further established that a machine designed to operate in a desanded pulp had the best chance of success because of superior screening efficiency. As a result, the work was concentrated on desanded pulps in order to speed up development of the process.

Two basic schemes were given consideration in initial equipment development studies. According to the first plan the resin actually moved continuously and countercurent to the flow of pulp in the adsorption cycle and continuously and countercurrent to the flow of eluant in the elution cycle. The second scheme involved a modified countercurrent system in which the resin was confined to containers or units through which the pulp or eluant flowed, the countercurrent effect being produced by intermittently advancing each unit in its respective circuit.

A thorough screening process of many suggested devices narrowed the choice to two machines, each typical of the two schemes noted above. The procedure having the characteristics of a continuous countercurrent system was a system of trommels

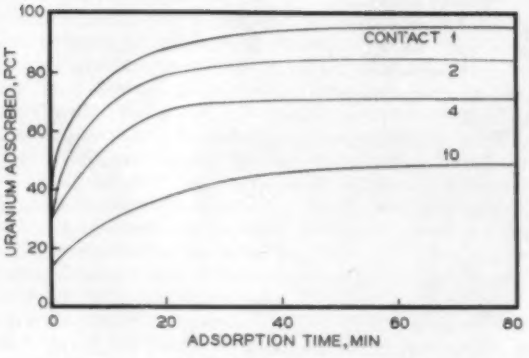


Fig. 1—Effect of extent of loading and contact time on uranium adsorption.

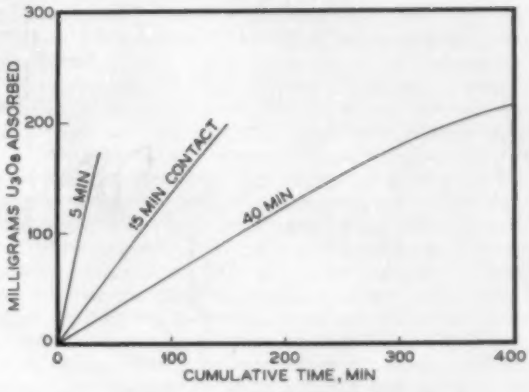


Fig. 2—Effect of contact time on steady state loading.

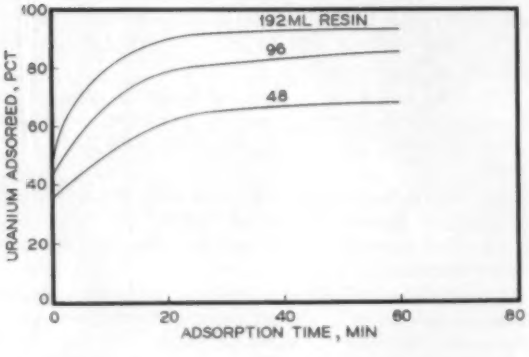


Fig. 3—Effect of solution to resin ratio on uranium adsorption.

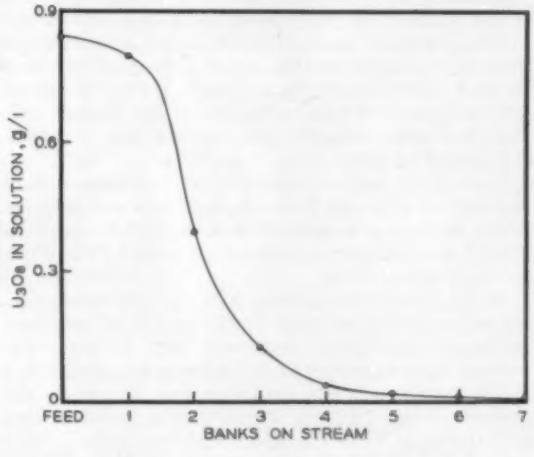


Fig. 4—Decrease of uranium concentration in solution from bank to bank.

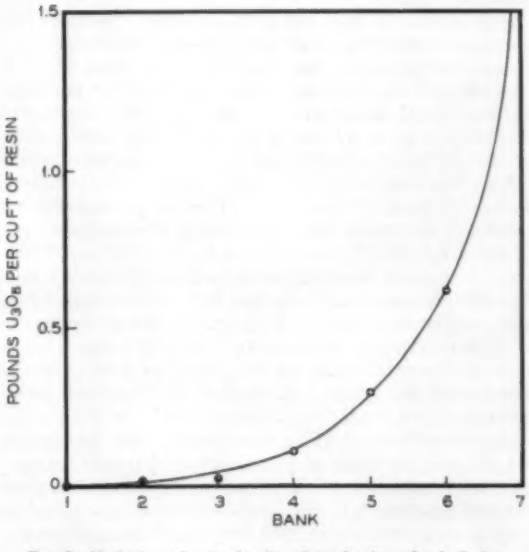


Fig. 5—Variation of resin loading from bank to bank during elution cycle.

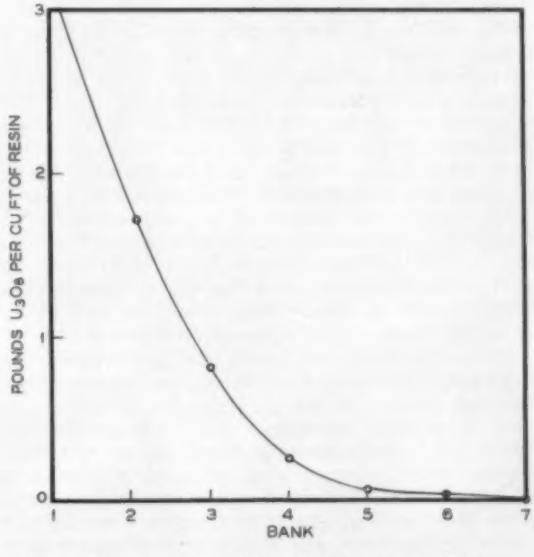


Fig. 6—Variation of resin loading from bank to bank during loading cycle.

and agitators in which the resin beads were advanced from tank to tank by elevating with lifter bars. This method had the advantage of continuous operation and low capital cost. Work was suspended on it, however, in favor of a basket machine arrangement, as it was not certain that the trommel arrangement would provide the most important requisites for successful operation, namely, metallurgical control, low resin loss, and positive control of resin to pulp ratio.

The basket arrangement, which ultimately was installed in the pilot plant at Grand Junction, Colo., in early 1953, was an adaptation of the modified intermittent countercurrent scheme. Development of the basket machine began in the laboratory, where bench-scale batch loading and elution tests were made to prove the applicability of RIP. Cloth bags and small wire baskets containing the beads were slowly moved up and down in containers of pulp or solution and advanced intermittently. The basic principle employed in the pilot plant is no different from that used in the early and seemingly primitive methods which demonstrated the process was possible. Baskets in the present machines are slowly moved up and down for the same basic reasons, namely, to contract and expand the bed of beads so that satisfactory contact with the pulp can be effected. At the same time, mild agitation is produced which improves circulation and prevents settling of solids.

The 18-in. baskets operate with fourteen 6-in. strokes per min; the 72-in. baskets operate with four 20-in. strokes per min. Wet settled resin depth in the 18-in. machine is about 6 in. and in the 72-in. machine about 16 in.

The first unit installed in the pilot plant contained six stages or banks. Each bank, separated into compartments by baffles, contained four baskets. The baskets were constructed of a hard maple framework rigidly supported and held together by tongue and groove joints. The top of the basket was left open and the remaining five sides enclosed with Ludlow Saylor No. 281, 8x28 mesh Rec-Tang screen bolted to the framework. The bolts were 18-8 stainless steel and the screen was woven with Carpenter 20 stainless steel wire.

The baskets were actuated in pairs by ¼-hp gear motors. These gear motors were connected to a shaft by a chain drive. On the ends of the shaft were eccentric plates upon which was bolted a crank pin. Rotation of the shaft was translated into a vertical movement of the basket by means of a connecting rod. No guides were provided in the first design and each basket was allowed to move up and down freely within the confines of its compartment. The length of stroke on this machine was made adjustable by several holes drilled in the eccentric plate at various distances from the center line of the shaft. Speed of the baskets could be varied by changing the sprocket ratios on the chain drive.

Early test work, both in the pilot plant and in the laboratory, indicated that the original six-bank system did not provide enough flexibility. It was necessary to load with five banks on the exhaustion cycle while the sixth bank was being eluted in a six-contact batch countercurrent process. A great deal of fundamental information and operating experience was obtained from this original basket installation, however, and results were so encouraging that a new and larger plant was built in 1954. From the experience and metallurgical data accumulated in the original installation, certain improvements were made with respect to details in design and bank arrangement.

The ore is ground in a ball mill and the pulp overflows the classifier at 50 pct solids. This pulp is pumped to acid-proof Deveraux agitators and leached with sulfuric acid. Four drag classifiers using two cyclones desand the overflows of the first two classifiers. This produces a −325 mesh slime containing approximately 8 pct solids which is pumped to the RIP units. Since the concentration of dissolved uranium in the pulp being fed to the RIP circuit affects the operation of the adsorption section, efforts should be made to avoid unnecessary dilution of the feed. The amount of water added should not exceed minimum requirements for washing the sands and adjusting the pulp density. The dilution water added during classification normally acts to increase the pH of the feed to about 1.5. Flow rate of the RIP feed depends on the slime content of the ore, but the average is about 0.65 gpm per ton of ore treated per day.

Information gained in the original pilot plant installation and data obtained in the laboratory had demonstrated that the following conditions are conducive to good metallurgy in the basket RIP process:

1) The volume ratio of pulp to wet settled resin should be approximately 6 to 1.

2) The minimum number of banks on exhaustion for a normal pulp should be six; a maximum of nine could be used for low grade pulps and high flow rates.

3) Total pulp residence time with six banks on exhaustion should be approximately 100 min.

4) The minimum number of banks on elution should be six.

5) The feed pulp to the exhaustion circuit should contain less than 10 pct solids and should be essentially all −325 mesh (less than 43 μ).

On the basis of the above requirements, the new RIP circuit was designed with 14 two-cell banks. Thus, under normal conditions, the circuit can be operated with six banks on exhaustion and six on elution with two banks as spares to permit changeover.

Operation of the Pilot Plant RIP Circuit: The principal operating variable for an RIP circuit is length of time between changeovers. This time is determined by the rate of introduction of uranium to the circuit and the uranium capacity of the ion exchange resin. In the pilot plant RIP units, each of the 14 two-basket banks contains 2 cu ft of resin which has a capacity of about 3 lb of U_3O_8 per cu ft. When all banks in the adsorption section have been operated for some time and are at steady state, the lead bank will become saturated every 3 hr. When this occurs, the feed stream is switched from the lead bank to the second bank, and the pulp remaining in the lead bank is discharged and rinsed through the rest of the banks in the series. At the same time, a new bank, containing barren resin, is added to the tail end of the adsorption section, the overflow going to tails.

At the time of the changeover, the last bank should still be making a satisfactory barren; its performance determines the number of banks to keep on exhaustion. If tails are high at the time of changeover, obviously it is necessary to put an additional bank on exhaustion or reduce the uranium throughput per cycle.

The elution operation is controlled by the volume of eluant necessary to elute the uranium completely from one bank of loaded resin. As the elution cycle starts, the six banks in the elution section are full of eluting solution. A seventh bank, which contains loaded resin just taken off adsorption, but no solution, is added to the downstream end of the elution section. The solution in each bank is now transferred one bank downstream. The flow so produced fills the newly added bank and empties the lead bank. The resin in the empty bank is rinsed free of entrained eluant and the rinse water is pumped through the circuit. The empty bank is now removed from the elution section and placed on standby for use in the adsorption section. Barren eluant is next pumped into the new lead bank, displacing solution from bank to bank until an equivalent volume of uranium-rich eluate is discharged from the last bank into the precipitation tank. The volume of barren eluant pumped into the system is determined by the uranium concentration in the discharge from the lead bank. When its concentration drops to 0.1 g of U_3O_8 per liter, the flow of eluant through the system is stopped until the next changeover. In the pilot plant RIP circuit, approximately 86 gal of eluant are used per changeover. Pulp and eluate transfers are made by a system of airlifts, discharging into a distributor that provides for transfer to the tailings pond, to the next bank downstream, or to the precipitation tank.

The pregnant eluate, which normally contains 8 g of U_3O_8 per liter, is precipitated by neutralizing with ammonia or magnesia. Resultant slurry is filtered and washed in a filter press. The washed cake is then dried in a tray drier. The grade of this product is 75 to 80 pct U_3O_8. The barren filtrate is adjusted to 56 g of nitrate per liter by addition of ammonium nitrate and then acidified to pH 1.2 with sulfuric acid. Total reagent consumption per pound of U_3O_8 recovered will vary with the degree of saturation of the resin. Pilot plant operating data indicate an average consumption of 3.8 lb ammonium nitrate, 1.8 lb sulfuric acid, and 1.0 lb ammonia.

During two years of RIP pilot plant operation, equipment performance has been remarkably trouble-free. At no time has it been necessary to shut down for mechanical failure of the RIP units. The original baskets, which are of wooden construction, are still in operation, and no screen changes have been necessary. Mechanical stability of the large bead resins has been found to be exceptionally good. Total resin loss due to attrition in two years of operation has been 23 pct. During this two-year period, the resin was actually on stream for 8070 hr. Loading capactities have decreased about 10 pct, but adsorption and elution rates appear to be unaffected.

No serious process difficulties have been encountered since the first pilot plant demonstration of the RIP process. However, if the ore being processed contains vanadium, it is necessary to be sure that the dissolved vanadium is present in the reduced form. Pentavalent vanadium adsorbs on the resin and is not eluted by the regular elution solution. Adsorption of vanadium is not permanent as it can be stripped from the resin by the use of sulfurous acid. However, the best answer to the problem is to avoid its being adsorbed. To insure that the vanadium is in the +4 oxidation state in the pulp, enough powdered iron is added at the end of the leach to produce a terminal emf of 0.45 v (vs S.C.E.).

Commercial Design Considerations: Assume that it is necessary to design an RIP circuit for a mill treating 450 tpd of ore containing 0.3 pct U_3O_8. To determine the number and size of baskets needed in the RIP circuit the following procedure would be employed:

1) Estimate the cycle time. Pilot plant test work has indicated that a minimum cycle of 2 hr can be used. For design purposes a 3-hr cycle is assumed.

2) Determine the uranium input per cycle. Since 450 tons of ore are to be processed per 24 hr, 56.2 tons of ore are being fed to the leach circuit every 3-hr cycle. This is equivalent to 337 lb of U_3O_8 for an ore containing 0.3 pct U_3O_8. Assuming, in this instance, a 90 pct solubilization, then 303 lb of U_3O_8 will be introduced into the RIP circuit every cycle.

3) Determine the resin inventory per bank. For a resin with an operating capactiy of 3 lb of U_3O_8 per cu ft, 101 cu ft will be required per bank, since during each cycle one bank containing 303 lb of U_3O_8 must be removed from the adsorption section.

4) Determine the number and size of baskets per bank. The largest basket constructed and tested to date has been a unit 6x6x6 ft. A basket of this size has operated efficiently with a resin inventory of 50 cu ft. Thus, each bank would consist of two 6-ft baskets.

5) Determine the total number of banks in the circuit. As indicated earlier, a minimum of 14 banks is required for efficient operation and flexibility. This assumes six or seven banks on exhaustion and six on elution and one or two on standby. With very low grade feed, however, the requirement may increase to 16 banks to provide for high recovery and efficient elution.

Wherever possible, the number of banks required should be determined from pilot plant tests.

Discussion

Data obtained in the pilot plant testing of the RIP process on the ores from seven different ore-producing districts of the U. S. have resulted in the RIP process being incorporated in all the new plants now under construction or in the design stage. RIP represents the successful solution to a problem that has been studied as long as hydrometallurgy has been practiced, namely, the elimination of the liquid-solid separation before recovery of the dissolved values. The advantages of the RIP process are:

1) Complete independence from the physical properties of the ores such as filtering and settling characteristics.

2) Better than 9 pct recovery of the dissolved uranium values.

3) A final product that averages 75 pct U_3O_8 or better and is free from elements that would be deleterious to processes used in the refining of uranium metal.

4) Low mechanical maintenance costs.

5) Dependable mechanical and metallurgical operation resulting in a high percentage of operating time.

6) Flexibility with regard to tonnage of ore treated, as the capacity, within limits, is based on uranium throughput.

At the present time, the RIP process is being applied to the recovery of uranium from alkaline leached pulps. Test work is currently in the pilot plant stage, and although several process problems exist, highly encouraging results have been obtained.

Crestmore Makes a Change

The shift from block caving at Crestmore to large-scale room and pillar mining has been a success. Mining costs, including depreciation and increased labor rates, are still very close to the old quarrying costs.

by R. H. Wightman,
P. B. Nalle,
C. D. Chandler

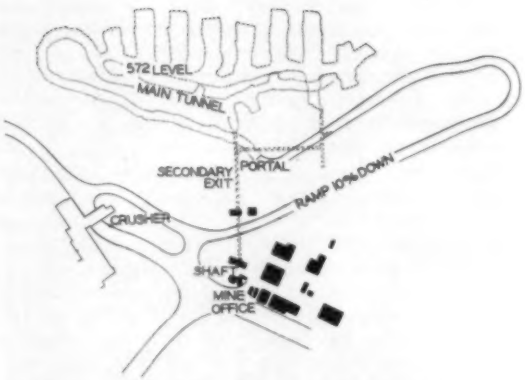
SURFACE quarrying at the Crestmore Div. of Riverside Cement Co. in California was started in 1909. In the early 1920's it was considered that these deposits were nearly exhausted for the equipment available at that time, and in 1927 the company began a block caving system. This mine continued operating until February 1954.

In 1941 trucks and crawler-mounted shovels had reached a stage of development that permitted reopening the quarries in conjunction with the underground mine. In 1948 surface reserves and the well developed limestone of the caving system neared depletion. To go deeper with the caving system was unattractive because of the economics, changes in physical structure of the rock at depth, and the perched water table.

In 1949 it was decided to restudy the deposits and develop a new mining method. A diamond drilling program, continued until the middle of 1953, proved there was enough suitable limestone to operate the plant for many years and justified the study of a new mining method.

The drilling program showed that the two beds extend about 2500 ft along the strike and are cut off at each end by quartz diorite. The limestone beds are a crystalline, metamorphosed rock with varying amounts of brucite. At the surface the beds dip at about 45° and flatten out to about 25° at depth. Separated at the surface by 500 ft of quartz diorite, the two beds converge to the east, where they are separated by only 100 ft of diorite.

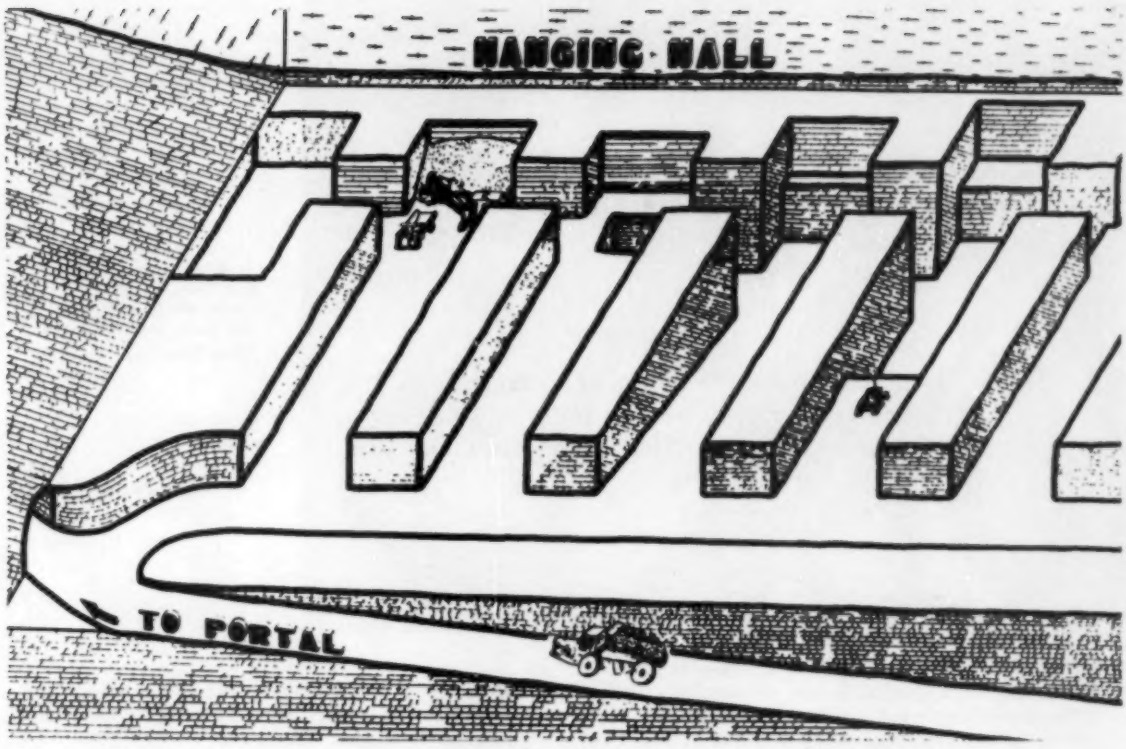
R. H. WIGHTMAN is Superintendent of Mining, P. B. NALLE is Mine Superintendent of the Crestmore Division, and C. D. CHANDLER is Chief Mining Engineer, Riverside Cement Co., Riverside, Calif.



Plan map of Crestmore operation. After 23 months of operation about 950,000 tons of rock have been produced.

Drilling showed that the northern end of the lower limestone bed was covered with water-saturated alluvium. All diamond drilling penetrating both beds was cased in such a manner that the water level in each bed could be measured independently. From the early mining it was indicated that the lower bed could be unwatered without disturbing the general water table.

A test well and pumping tests in 1953 proved that the entire lower bed was very permeable and could be unwatered without disturbing the water table. A granodiorite and clay capping keeps water inflow to the limestone at a reasonable amount, and any mining method considered would have to keep this capping intact.



Crestmore Mine—Riverside Cement Co.

Choice of Mining Method: From the standpoint of plant requirements the following conditions would have to be met:

1) The method must be very economical.

2) It must be capable of increasing or decreasing production without too much difficulty.

3) It should permit some flexibility as to choice of materials.

With respect to the orebody there were other conditions:

1) To maintain protection from the water-saturated alluvium, the method must allow no subsidence.

2) It must be adaptable to the varying dips of the deposit.

Finally, and most important, the method would have to be safe and not too complicated for non-mining personnel.

Choice of methods narrowed down to the familiar room and pillar type. Two models were made, one showing the orebody and its environment and the other showing the proposed plan. These models were very useful in demonstrating to non-mining personnel of the company just what was being planned. The final plan was to cut an open road down through the old block-caved area, and when solid ground was reached, drift down the footwall on a 10 pct grade.

When the old workings were far enough above the main tunnel, a level drift was to be run parallel to the strike and rooms 60 ft wide by 30 ft high were to be turned off from this drift at right angles to the strike. Pillar width was set at 50 ft. Two 30-ft benches were to be taken from the rooms, making the final height 90 ft. The main tunnel was to continue down the footwall, making switchbacks as necessary to open up successive levels. A floor pillar was to be left between levels to limit stope height to 90 ft.

Average Underground Crew at the Crestmore Mine

Salaried	
Superintendent	1
Head mine foreman	1
Mine foreman	4
Engineers	2
Mine clerk	1
Subtotal	9
Hourly	
Shovel operators	3
Pitmen	3
Truck drivers	12
Scaling crew	2
Drillers and powdermen	10
Powder clerk	1
Utility men	2
Laborers	2
Relief and miscellaneous	3
Compressor operator	1
Subtotal	39
Total	48

The open cut work for the main drift was completed by March 1955 and the tunnel itself was started. At this time, a submersible deep well pump began dewatering the deposit.

All development work has been done with a Rogers crawler-mounted, two-machine jumbo, operated by a two-man crew. Mucking and hauling are done with a Marion 43-M electric shovel with short boom and stick, loading into four Le Tourneau Model C *Tournarockers*. The tunnel size is normally 30 to 32 ft wide by 27 ft high. The tunnel cycle is currently geared to a 24-hr, three-shift basis as follows:

First shift	3 to 4 hr	Scale and move jumbo in
	4 to 6 hr	Drill
Second shift	2 to 4 hr	Finish drilling and move out
	4 to 6 hr	Load and blast
Third shift	8 hr	Scale and muck out

Ingersoll-Rand, crawler-mounted, four-machine jumbo which drills out the 60-ft wide face in two setups.

All rounds are drilled as V cuts, inasmuch as there is sufficient width to get a good angle at the V. The jumbo is so designed that the V angle is automatically controlled once the machines are set. A normal round requires about 60 holes, but the number varies slightly with the type of rock. A 10 to 12-ft advance is made per round, breaking from 700 to 800 tons. The haul from the main tunnel face is now a mile and a quarter, of which all but 200 yd is on a 10 pct grade.

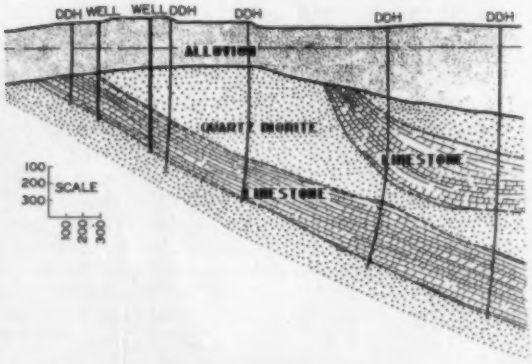
Work in the rooms, or stopes, started about a year ago, when the Ingersoll-Rand crawler-mounted, four-machine jumbo was moved underground. This jumbo, which drills the 60-ft wide face in two setups, is also designed to drill a V-cut round. The number of holes required for an entire face varies from 110 to 120, depending on the type of ground. Scaling, drilling, blasting, and moving in and out require about four shifts with two men per shift. Any major scaling and roof bolting jobs are done by a special crew. The rooms are wide enough so that any minor work can be done on one side of the room while drilling is proceeding on the other.

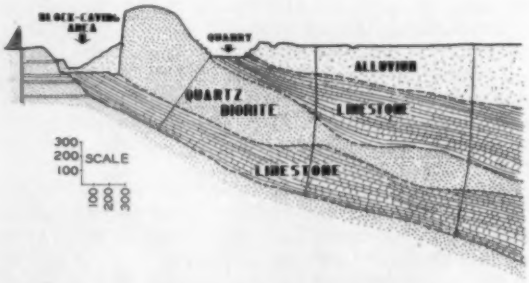
Mucking is done by 93-M Marion electric shovels, equipped with 3-yd bucket and short boom and stick, loading into either the Tournarockers or Kenworth electric trucks. These shovels can work in a room 45 ft wide by 30 ft high.

Electric trucks were chosen for several reasons. Less overall ventilation is required than for diesels. They are also faster on the grade and less costly to maintain.

Built by Kenworth especially for Riverside Cement Co., these trucks operate under a standard 550-v, dc, trolley coach, two-wire system. Main drive is a 350-hp General Electric traction motor located where the clutch and transmission would be in an ordinary truck. A mill-type, 20-hp motor operates the hoist, the generator for the 24-v light and control circuit, the power steering, and the air compressor. A reel and reel-drive motor under the hood is used when a truck is backing under the shovel, allowing the driver to move 400 ft from the trolley line.

Two GE Ignitron rectifiers supply the power for these trucks. Rated at 400 kw each at 575 v, with large overload characteristics, the rectifiers are fully protected and operate automatically. One is located





Cross section of Crestmore deposit. The drilling program showed that the two beds extend about 2500 ft along the strike and are cut off at each end by quartz diorite.

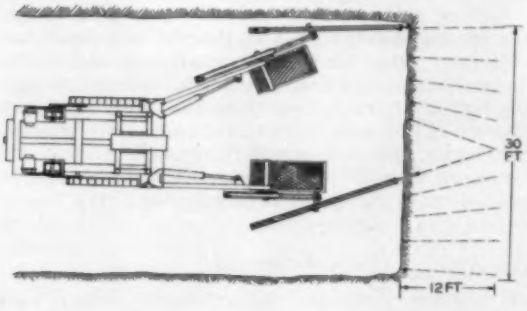
Kenworth electric trucks powered by General Electric equipment. Trucks operate under a standard 550-v, dc trolley coach two-wire overhead system.

on the surface and one about halfway down the haulage road. To keep the voltage drop at a minimum, they are parallel-connected with short feeder cables.

A normal room round breaks about 2000 tons of rock. There is practically no secondary blasting in the rooms. It is interesting to note that in the drilling statistics below, which are average for the entire mining period, there is very little difference between the tons of rock per foot of hole, or pound of powder, in development and production drilling.

Drilling Statistics for a 2-In. Hole

Footage	
Feet of hole per carbide bit	2133
Feet of hole per foot per 1¼-in. round steel	42
Feet of hole per jumbo shift—development	826
Feet of hole per jumbo shift—production	1048
Cost	
Tons of rock per foot of hole—development	$0.80
Tons of rock per foot of hole—production	$0.95
Tons of rock per pound of powder—development	$1.58
Tons of rock per pound of powder—production	$1.57

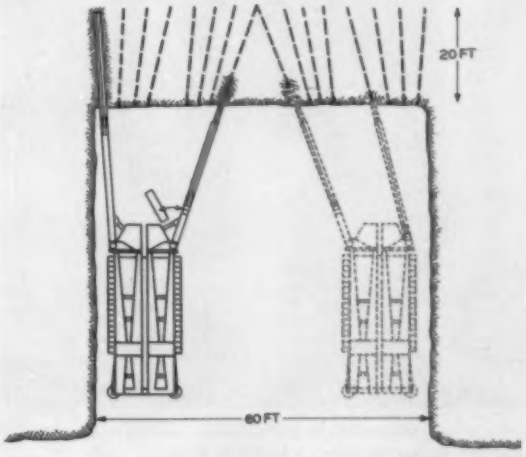


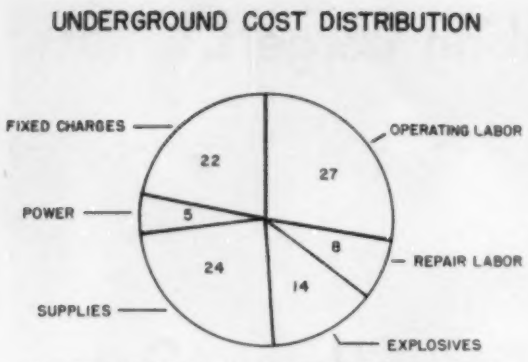
Two typical patterns showing V cut with which all rounds are drilled. Ten to 12 ft of advance are made per round, breaking from 700 to 800 tons.

One reason the difference in efficiency shown for the two-machine and four-machine jumbo is not greater is that it is harder to break in a crew to operate the four-machine jumbo. As the men become more proficient this difference will increase, but it will never double the drilling rate of the small jumbo.

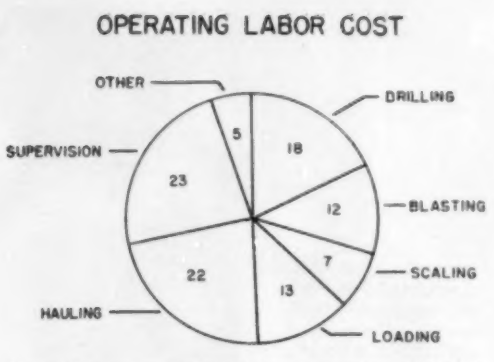
After the rooms have been driven from footwall to hanging wall, two Gardner-Denver 4½-in. crawler-mounted wagon drills are used to advance a 30-ft bench, making the rooms 60 ft high. To date, only one and a half rooms have been made 60 ft high, so that drilling rates and powder factors for bench drilling are not accurately known. However, the trend is bearing out the expectation of lower cost per ton for breaking bench rock.

All powder loading and scaling are done from two scaling rigs built on retired qaurry trucks. One is homemade and will put a man high enough to reach and roof-bolt a room 32 ft high. The other, a Pitman Giraffe, will reach a height of 65 ft. The short scaling rig is cable-operated from the truck cab, and





Percentage breakdown of underground mining cost for the last quarter of 1956.



Direct labor costs showing the large percentage allotted to supervision and haulage.

the high Giraffe is hydraulically controlled from the scaling basket. Other auxiliary equipment includes a D-8 cat and dozer, 2¼-yd skip loader, water wagon, road grader, and various supply trucks. All auxiliary underground equipment is diesel-driven and scrubber-equipped.

It is interesting to examine the method as far as it has progressed and to compare it with more traditional systems of mining. One of the points discovered is that the system and equipment can be rapidly picked up by non-mining personnel. Quarry drillers, shovel runners, and truck drivers made the transition from open pit work to underground with very little trouble. Early in the operation it became apparent that the overall tons per manshift and cost per ton would meet original estimates. After 23 months of operation about 950,000 tons of rock have been produced. Half of this amount is development work.

Pitman Giraffe which is hydraulically controlled from the scaling basket can reach a height of 65 ft.

Mining Costs with the New System: Results of the extensive mechanization program are shown in the accompanying diagram, a percentage breakdown of underground mining costs for the last quarter of 1956. The direct labor figure is perhaps lower than usual for a mining operation, and the fixed charges, mostly depreciation and taxes, are higher. Experience of past years, however, has shown that with a steadily and rapidly rising labor cost per hour it is better to lower the total labor cost at the expense of increasing fixed costs.

A separate diagram of direct labor costs reveals the large percentages allotted to supervision and haulage. The policy of providing salaried supervision for all phases of the work has been largely responsible for the success of the operation. Four foremen, one head mine foreman, and a mine superintendent are included in the supervisory group covered in the direct labor breakdown. These six men have about 40 hourly paid men working under them. Also in the supervisory group are two engineers and one clerk. There are never more than 12 men on a shift at any one time. All underground work is conducted on a round-the-clock basis seven days a week. Maintenance is handled by one foreman and eight men.

When two or three levels have been completed, a careful study will be made as to the possibility of installing conveyor haulage from an underground crusher. If such a plan is adopted, it will again lower supervisory and haulage costs and increase depreciation charges.

Mining costs to date, including depreciation and the increased labor rates of the last two years, are still very close to the old quarrying costs. The method has proved flexible enough, however, to supply both the varying quantities and qualities of rock needed by the plant. There have been minor changes in the plan and undoubtedly there will be more, but these can be made as required, which would not be possible with the block caving system.

References

A. O. Woodford: Crestmore Minerals: *California Journal of Mines and Geology*, 1943, vol. 39.

E. M. Machevett: Geology of the Jurupa Mountains, San Bernardino and Riverside Counties, California. California Division of Mines, *Special Report No. 3*, 1951.

C. W. Burnham: Geology of Southern California. California Division of Mines *Bull. 170*, 1954, pp. 61-70.

C. A. Robotham: *USBM Inf. Circ. 6795*, 1934.

R. H. Wightman: A New Caving Procedure at the Crestmore Limestone Mine. *Mining Technology*, Nov. 1944, TP 1766.

P. B. Bucky: *Mining by Block Caving*, pp. 88-101. Hercules Powder Company, 1945.

Sinking Large Diameter Mine Shafts by Rotary Drilling

by Victor Zeni and Thomas N. Williamson

A 6-ft diam core drilling machine has successfully completed seven mine shafts in Virginia and West Virginia to depths as great as 465 ft. There is no practical depth limitation to this new system—a potential method in formations not easily penetrated with other large-scale drilling programs—and higher penetration rates and larger diameters are possible in some formations already being drilled successfully by other methods.

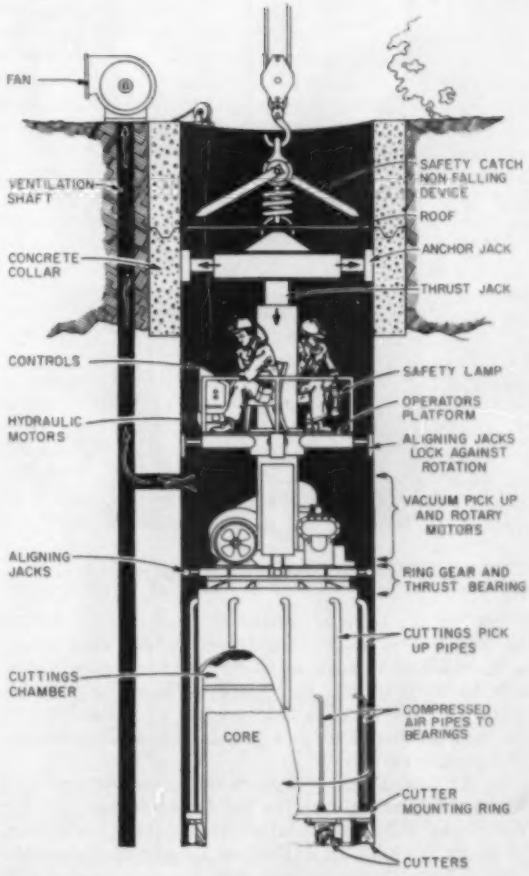
The core barrel on the machine is fitted with rolling cutters such as those used on oil field rotary bits, so that less torque is required than with other large-scale drilling systems. The core is made with a wider kerf than is achieved with other coring methods, providing more working room for core drilling.

Machine Development: In the early 1950's the Zeni Corp., a shaft sinking company, foresaw an expanded need in the mining industry for large-diameter drilled shafts to be used for portals, ventilation, or access. After studying conventional shaft drilling methods and other small-hole methods available, the corporation investigated the oil field rolling cutter.

This method of rock drilling was being accepted by the mining industry for blastholes in diameters from 4¼ to 12¼ in. The possibilities of coring or of drilling all of the bottom of the hole were both considered. Removal of the vast amount of cuttings, the need for tremendous thrust on the bit, and other considerations made it desirable to core. Special cutters would be required, since none were available to roll in these very large diameters or to cut a practical kerf width.

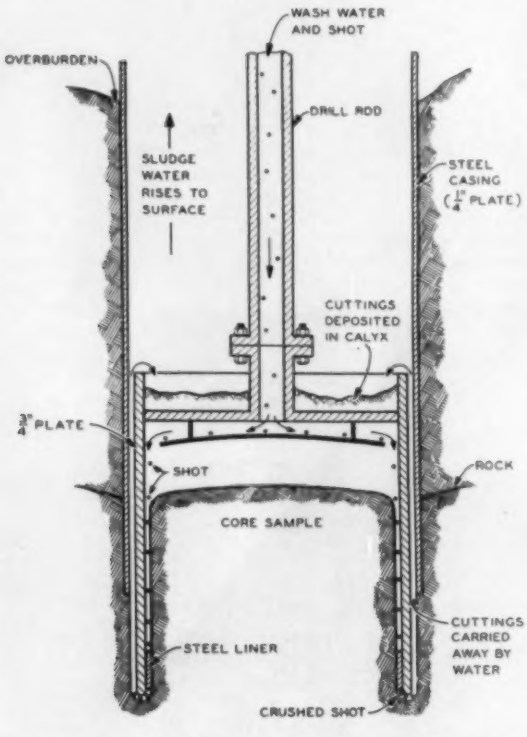
The drilling rig developers decided to build a machine that would go into the hole on a wire line. Since the rolling cutter drills by overcoming the compressive strength of the rock, the machine would be designed to apply a thrust of at least 100,-

VICTOR ZENI is with Coal State Construction Co., Morgantown, W. Va., and T. N. WILLIAMSON is with the Engineering Dept., Hughes Tool Co., Houston, Texas.



Zeni shaft sinking machine. Estimated cost of drilling machine and auxiliary equipment is $100,000. Drilling machine weighs about 25,000 lb. Drawing by W. L. Myers, Jr.

The machine is equipped to mount two sets of cutters with six in each set, but only one set of six is currently being used.



Calyx drill. Holes have been drilled as large as 5½ ft diam.

000 lb on the bits. It would be capable of rotating the core barrel at seven different rotary speeds between 0.9 and 15 rpm, as there was no prior experience to narrow this rpm range. Thrust was to be applied to the core barrel and bit by anchoring to the wall of the hole and using hydraulic pressure against this anchor.

At the beginning of this development it was believed that the volumes of air or mud required for positive or direct circulation would be prohibitive. To clean the kerf, in either wet or dry drilling conditions, vacuum equipment was incorporated in the design.

Cutter Development: After determining that a kerf 4 in. wide would be practical, Hughes Tool Co. engineers designed a cutter to roll in a 75-in. diam hole. This particular design will work satisfactorily in any diameter from 5 to 8 ft. Mounted on a conventional bit bearing of the tri-cone type, the cutters are bolted to a ring on the lower end of the core barrel. The angle of the bearing pin is such that as the bearing wears the cutter is forced out, compensating for gage wear. There has been no serious difficulty in getting back to bottom with a new set of cutters because of an undersize hole.

Before tests of equipment and method had begun at the Hughes laboratory, rig developers had started assembling parts for the machine. Design and development progressed concurrently with machine construction, with many improvisations for the sake of expediency. Trotter Coal Co., the first shaft customer, was very cooperative during this stage of development.

An accompanying sketch shows the principle of operation. A vertical thrust jack works against a horizontal anchor jack applying a load to bits on the rotating core barrel. Both jacks are hydraulically operated and are controlled from a central panel.

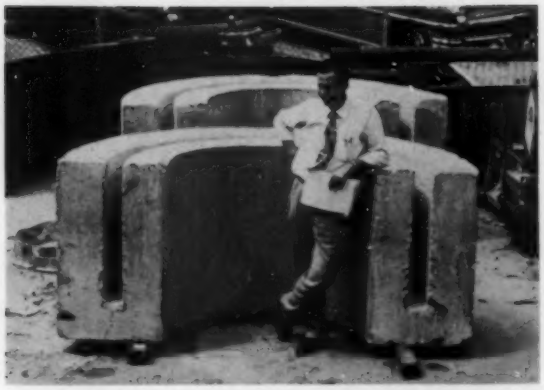
A 7½-hp industrial vacuum machine was used for cuttings removal. A 25-hp electric drive motor for the rotary and a 7½-hp motor for the hydraulic pump were provided. As no suitable hydraulic cylinder for applying thrust was readily available on the market, one was made from 16-in. casing in the Zeni shop. The 10-ft core barrel, of 70-in. diam, was fabricated from ½-in. plate. Steel angles were welded longitudinally for rigidity and strength. A cuttings chamber was made by installing a floor at about midlength inside the barrel.

A two-way swivel was designed and fabricated to permit simultaneous vacuum pick-up of cuttings and the passage of compressed air to the bearings for cleaning and cooling. A large ring gear and a thrust bearing were mounted on top of the barrel. A heavy duty truck transmission and differential were mounted between the electric drive motor and a vertical shaft with pinion, which engages the ring gear on the barrel.

The operator's platform, on which all controls are located, was placed just above the midpoint of the mechanism above the core barrel. Small mechanical screw jacks were installed horizontally at the top of the core barrel and at the operating platform level to assist in maintaining a straight hole and to help prevent rotation of that part of the machine above the core barrel. Owing to the plumb bob action of the machine these screw jacks have not often been needed for directing the hole.

The large horizontal anchor jack is at the top of the thrust jack. The hook on top of this anchor, by which the machine is lifted, is equipped with a spring-loaded mechanism that will grab the wall of the hole to prevent the machine from dropping should a wire rope break while it is going into or coming out of the hole. A round hinged roof with door on top of the anchor jack protects the men and machine from falling debris. So far there has been practically no spalling of the smooth shaft wall.

The machine is equipped to mount two sets of cutters with six in each set, but only one set of six is currently being used. Six cutters provide a sufficiently smooth operation and a higher unit loading on each cutter with the thrust available. Use of fewer than six cutters at one time is not recommended, as three of the six cut the inside half of the 4-in. kerf and three cut the outside. Each of the



A core barrel for laboratory use was equipped with a two-way swivel to permit cuttings to be picked up with vacuum and air to be pumped to bearings to keep them clean and cool.

This 6-ft diam core drilling machine has successfully completed seven mine shafts in West Virginia to depths as great as 465 ft.

three cutters in each path has different numbers of teeth so that any rock gear formed by one cutter is broken up by the others.

A stiff leg derrick on the surface originally handled the equipment and core pulling chores satisfactorily but has recently been replaced by a truck crane.

Cost of the drilling machine and auxiliary equipment is estimated at approximately $100,000. The drilling machine alone weighs about 25,000 lb.

Starting the Hole: In starting a new hole, surface excavation is done by clamshell or other conventional means through the soft surface to bed rock or to a depth of about 30 ft, whichever is less. A 6-ft ID precast concrete shaft collar is inserted in this excavation. This heavily reinforced precast concrete pipe is in easily handled lengths which interlock.

Five to 10 shifts are required to move in the set-up and tear-down equipment for each shaft.

Water and Ventilation: Preliminary plans were to handle water, as it was contacted, by grouting through short jackhammer-drilled holes in the bottom of the shaft or through bulkheads in particularly troublesome areas. After the first shaft this plan was abandoned in favor of pregrouting the complete area through an 8-in. hole at high pressures. Short sections are plugged at a time, starting at the bottom. This grout finds its way into all crevices in the area of the shaft and stops all the main water flow in those areas where it has been used.

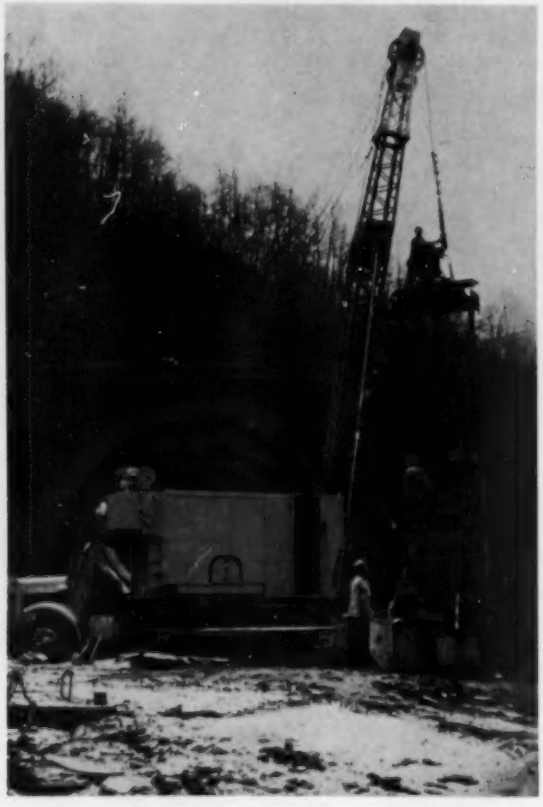
Since it is located just outside the proposed shaft circumference, the small grout hole is later redrilled and used for ventilation. A suction fan placed on top of this hole draws air down the shaft and up through the hole. The shaft sinkers tap into the adjoining hole at frequent intervals to keep air circulation close to the work. A 12-in. canvas blower sock originally provided for ventilation was thus replaced. Some of the seepage water is also removed as mist in the air drawn through this hole.

Water has been encountered in every hole, so that the machine has always operated in enough water to cover the cutters. This has so far eliminated the need for air to the cutter bearings. Air courses can be provided to clean and cool the bearings for dry drilling. The double swivel on the machine and separate pipes to each cutter permit compressed air from an outside source to be pumped to the bearings when a dry hole is being drilled. Dry drilling has been done using another circulation method by the U. S. Army Corps of Engineers. This system will be discussed briefly later.

Progress Data for Shaft No. 6 at Bunker Mine No. 2, Trotter Coal Co., Core, W. Va.

Diameter	75
Depth of shaft, ft	464.8
Depth drilled, ft	452.5
Total elapsed days (single shift) including holidays	79
Total drilling days	55
Feet per hour, including down time	0.93
Feet per hour, drilling time only	3.14
Feet per 8.8-hr shift	8.23
Feet per set of cutters	51.9
Feet drilled per trip	3.62
Trips per shift	2.27

Cutting Pick-Up: The vacuum system picks up cuttings and water, both of which are deposited in the cuttings chamber, which has a rubber flap valve on the outside of the barrel. The operator on the machine intermittently stops the vacuum motor,



Special truck-mounted crane for handling core and equipment. All electric power is connected to the crane.

Core catcher made of two large rings separated by several longitudinal steel plates slightly longer than the 5-ft core.

which allows the flap valve to open and the water to flow from the chamber back into the hole.

Crew: A crew of four men is needed, two on the machine while it is in operation and two on the surface. Except during the core pulling, only one man at each place is busy, and during the drilling these two are only operating controls and recording data. To take care of any emergency, during drilling, two men stay on surface and two in the hole. The men do not ride the machine into the hole. A separate line with special bucket is provided for this purpose.

Operation: In drilling, the anchor and thrust jacks are set, the vacuum motor is turned on, and the core barrel is rotated. Telephone communication is maintained between the hoist men and the machine operator, and drilling times, hydraulic pressures, and other operating conditions are recorded at 2-in. intervals. This telephone report not only provides an excellent log of operations but also gives constant contact between surface and machine for safety.

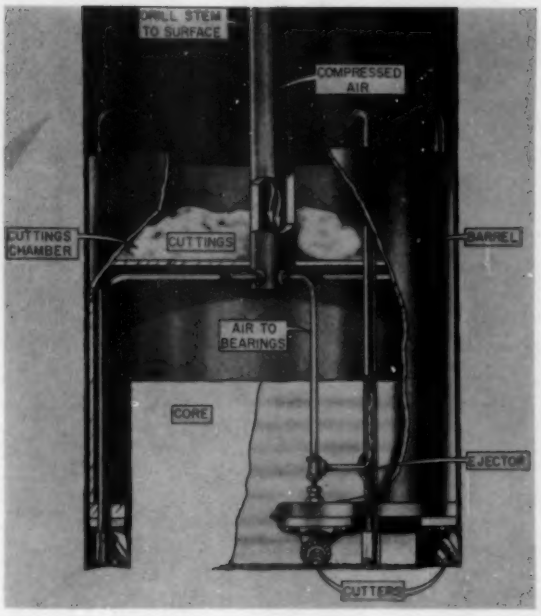
Core Pulling: After about 5 ft of core has been drilled, the drilling machine is withdrawn and the core catcher inserted. The catcher is made of two large rings separated by several longitudinal steel plates, slightly longer than the core. There are cams on the inside of the lower ring with steel rollers held in a track or a cage. As the catcher is pulled, these rollers are forced into the core by the cams. While other crew members are pulling the core, one of the crew shovels and rakes the cuttings out of the upper drilling machine chamber.

A slight explosive charge in a small jackhammer hole drilled to the bottom at the center of the core has broken off all cores satisfactorily. This is accomplished with less than half a stick of dynamite. Many cores are broken without any blasting. In drilling a 400-ft shaft of this type in West Virginia, it can be expected that 10 pct of the cores will break up in the hole and require hand loading.

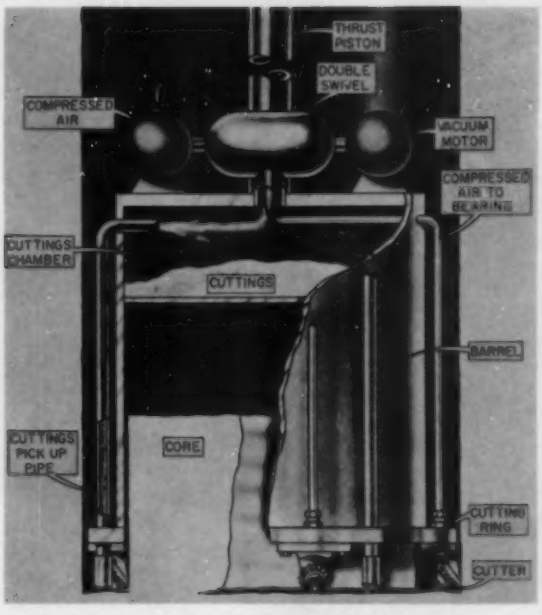
In dry holes the Army machine, previously mentioned and described later, had some difficulty in trying to break the core with a dynamite shot in the kerf. Two sticks of dynamite placed in the kerf against the lower part of the core and covered with several gallons of mud failed to break the core. One-fourth stick in a small hole drilled in the center broke them nicely.

Major Machine Revisions: Although the stiff leg derrick worked satisfactorily to handle this equipment, a special truck-mounted crane with more mobility was designed and built for the job. All the electric power is connected to the crane. From its control panels each piece of electrical equipment, both in the hole and on the surface, gets its power. The crane operator thus can start or stop the fan, the compressor, the power cable hoist, and the drilling rig at any time.

It was found after a few shafts that about 7 rpm would be satisfactory for all formations expected to be drilled. The multispeed transmission was eliminated to provide a stronger gear train. It was also found that 25 hp was inadequate for the rotary drive, and in its place two 25-hp permissible explosion-proof motors have been installed. Each of these has its own vertical shaft with pinion engaging the ring gear on top of the core barrel.



Vacuum circulation system.



Ejector circulation system.

Formations: Formations so far encountered in shaft No. 6 have all been sedimentary shales, limestones, and sandstones. They are soft, medium hard, and hard. No extremely hard formations such as granite or trap rock have as yet been drilled. Cutter life on shaft No. 6 averaged about 51.9 ft per set of six cutters. This is about average for all shafts. Cutter costs have been just under $8.00 per ft. Total costs of shafts of this diameter appears to be appreciably less than for other methods under comparable conditions. It appears from the data that on a three-shift basis, a 400-ft shaft could be completed at this location in 30 days.

Penetration rate has averaged about 3 ft per hr. Progress has been at the rate of about 8 ft per shift. Steps to reduce down time and increase the advance per shift are being considered on a machine to drill 8-ft diam shafts now being designed.

Other Related Tests and Developments

Army Tests: At their Research and Development Laboratories, Fort Belvoir, Va., U. S. Army engineers drilled 5-ft diam holes to 30-ft depths in hard limestone with a surface-operated rig. They obtained a vacuum by an aspirator or ejector effect with compressed air. This system worked very well, but the tests had to be stopped prior to the elimination of several mechanical weaknesses in the first set-up, as the machine was needed elsewhere on other types of work.

Casing: After the first Zeni shaft was drilled it was cased from the bottom up with 6-ft diam casing. Sections of casing 30 ft long were welded circumferentially in the shaft to the previously installed section. Special jigs and handling devices were needed for this work. Reamers and collapsible cutter mountings have been considered to allow casing to be done simultaneously with drilling in unstable ground in the future.

Man Cage: The Connelsville Mfg. Co. has designed a two-deck round elevator cage weighing 6500 lb to be used in these shafts. Ten men can be comfortably accommodated on each deck. This is a fully automatic passenger-operated counterbalanced system incorporating an overhead friction hoist and including many safety features. One of these is being used successfully in the first shaft drilled, regularly transporting 20 men each trip. About 1 min of travel time is required for 467 ft.

Positive Circulation to Clean Kerf: Subsequent laboratory tests have indicated that positive or direct circulation of air or water without using excessive volumes might be practical where formations or other conditions make it appear unwise to put a machine in the hole. This circulation method for large shafts, however, offers other problems not yet solved.

Conclusions

The rotary drilling system offers opportunities to drill shafts to 8-ft diameters and perhaps larger in any area where water can be economically controlled. Cutters have been made or designed for holes as small as 18 in. and for a wide variety of formations. Chief limitations on size are portability of equipment and the ability to break and handle cores.

The compact nature of the equipment makes it adaptable for drilling between levels underground. This system offers speed and economy in small and medium-sized shaft sinking. It also provides a finished hole with a minimum disturbance to the shaft wall and optimum conditions for ventilation if the shaft is to be so used. It appears to be one of the safest methods of shaft sinking so far devised.

Acknowledgments

The authors are indebted to the Zeni Corp. and the Hughes Tool Co. for providing the time and material for this paper. They wish particularly to thank E. A. Morlan, of Hughes Tool Research Dept., who was responsible for the laboratory work preceding this development and the design of the cutters.

New Horizons for Lithium

by P. E. Landolt

Most important single source of lithium in U. S. is the North Carolina spodumene belt. For example, Foote Mineral's operation, shown opposite, reports 13 million tons in proven reserves.

BEFORE World War I, and even prior to World War II, lithium was considered among the rare elements. Mining was limited to exploitation of a few well selected sources of rich minerals recoverable by hand cobbing methods. Within the past five years the situation has changed radically.

Many new sources have been explored and developed, principally in Canada, North Carolina, and Southern Rhodesia. The prime raw material for lithium recovery is spodumene. In Southern Rhodesia, however, both petalite, a modified spodumene, and lepidolite, a lithium mica, are being mined in quantity.

In the tin-spodumene belt in North Carolina two large chemical plants are supplied from spodumene ores mined by open pit methods—Foote Mineral Co. and Lithium Corp. of America Inc. A number of other companies, among them Basic Atomics Inc. and National Lithium Co., have explored this area and control considerable acreage. The tin-spodumene belt extends some 35 miles, from Lincolnton, N. C., to a point in South Carolina, just south of Kings Mountain, N. C. Width of this mineralized area varies from 2 to 14 miles.

While lithium minerals are found in many states of the U. S., the Black Hills area of South Dakota is still an important source of such raw materials.

Canada has become the source of a vast amount of lithium minerals, principally spodumene. The Val d'Or area of northwest Quebec is being mined by Quebec Lithium Corp., which operates a flotation mill to treat at least 1000 tpd averaging 1.25 pct Li_2O, upgraded by froth flotation to over 4 pct. The 160 to 200 tpd of this flotation product are shipped to Lithium Corp. of America Inc. at Bessemer City, N. C. Other sites in Quebec have been explored but to date are not producing.

P. E. LANDOLT is a Consulting Engineer in New York City.

In the province of Manitoba a number of locations show substantial quantities of spodumene. Principal areas are Cat Lake, Bernic Lake, and Herb Lake. Substantial showings of lithium-containing pegmatites have been reported in Ontario also.

From all observations to date, the vicinity of Yellowknife, Northwest Territory, north of Great Slave Lake, appears to have a most prolific amount of spodumene. An extended exploration and drilling program carried on during the past 12 to 18 months has revealed pegmatite dikes far richer than those found or developed in other areas. Ore averaging 2 to 4 pct Li_2O can be mined in large quantity by open pit methods. This may be compared with Quebec and North Carolina where the mined material averages 1 to 1.5 pct. The Black Hills and Manitoba areas may be somewhat richer than North Carolina, possibly 1.5 to 2 pct.

How extensive are the various reserves? At best ore values can only be indicated. With a thorough drilling program, *measured* or *proven* ore can be calculated. Beyond that, ore possibilities may be estimated as *indicated* and *inferred*. Experience of recent years has shown that tonnages actually mined will at least equal if not exceed the *measured* ore predicted.

From a review of published and other available material, the situation in the U. S. and Canada would appear to be as follows:

Region	Explored Reserves, Tons	Li_2O Pct
United States		
Black Hills, S. D.	3 to 5 million	1.5 +
North Carolina	100 million	1 +
Canada		
Quebec	20 million	1 to 1.5
Manitoba	15 to 20 million	1 to 2
Northwest Territory (Yellowknife)	100 million	2 +

A recent publication, "Lithium Resources of North

It should be remembered that these rough tonnage figures are shown to demonstrate the amounts of raw material that may be expected to be mined commercially. These ore reserves will adequately support growing lithium compound production.

Mining Methods: In the early period of the lithium industry spodumene crystals and aggregates were hand cobbed to produce a uniform concentrate, usually 6 to 7 pct Li_2O. Tonnage demands were limited and labor costs low, so that this method sufficed in pegmatite dikes having crystals of spodumene.

To develop the industry, it was essential that large quantities of ore be found and mined economically. This necessitated concentration as well. Lithium Corp. of America Inc. pioneered in this work.

In the Black Hills of South Dakota both open pit and underground mining methods have been used. In North Carolina present operations are open pit. Quebec Lithium Corp. in Quebec mines exclusively underground. When areas such as Yellowknife are opened up for mining, pit methods will be used initially. Mining will begin in the Yellowknife area within the next two years.

When very large-scale mining operations are undertaken, mass methods underground will probably be used to minimize unit mining costs.

Concentration Methods: Both heavy media separation and froth flotation are used in concentrating spodumene ores. It is possible to produce a high grade spodumene concentrate (5 to 6 pct Li_2O) by means of heavy media separation using ferrosilicon as the densifying agent. The method has the advantage of requiring a crushing operation to only $-1\frac{1}{2}$ in. to $-\frac{1}{2}$ diam, depending on the size and free-separation of the spodumene crystals or crystal aggregates. However, the -10 mesh material has to be removed before concentration—a considerable loss of lithium-bearing material. Furthermore, to obtain a substantial throughput, the concentrate economically produced contains 4 pct+ Li_2O.

Froth flotation, with crushing and grinding to about -48 mesh, produces a good concentrate. Here also, to make an optimum production a concentrate of 4 pct+ Li_2O would be obtained. Output would be sharply decreased by producing 6 pct Li_2O.

In heavy media concentration a recovery of 75 pct± of the lithium-bearing material can be made. By froth flotation about 65 to 70 pct of the lithium-bearing material is recovered.

There would be considerable advantage in applying heavy media techniques to bulk recovery of the lithium-bearing material. By combining the -10 mesh reject with the heavy media concentrate, and grinding to proper mesh, flotation can be more effectively treated. Accordingly the investment in concentrating equipment can be greatly reduced. Overall recovery from ore to finished concentrates would still be about 70 pct, but a concentration of at least 5 pct Li_2O could be expected.

The objection to such concentrating methods, particularly flotation, is the high cost of plant and high cost of operation, which increase the unit cost of Li_2O delivered to the chemical plant for recovery of lithium. For one ton of ore mined at $2.50 per ton, average of open pit and underground mining, and containing 1.5 pct Li_2O, costs are:

Per unit Li_2O	$1.67
Per pound Li_2CO_3 equivalent	$0.033
Per pound Li_2CO_3 equivalent on direct recovery from ore	$0.050 (65 pct yield)
Per pound Li_2CO_3 equivalent in 5 pct Li_2O concentrates	$0.104
Per pound Li_2CO_3 equivalent from concentrates	$0.16 (65 pct yield maximum)

At its Bessemer City plant, Lithium Corp. of America Inc. has fully demonstrated the practicability of direct ore treatment, which appears to offer considerable advantage. However, this necessitates a chemical plant adjacent to the mine. Where shipment of such raw material is necessary, only con-

centrates can be shipped because of the costs of

A recent publication, "Lithium Resources of North Carolina,"[1] provides a comprehensive summary of deposits in that state. A quotation from this report is illuminating:

Several estimates of the spodumene reserves in the tin-spodumene belt have been published in recent years. These vary widely, depending upon the limiting factors used and the subsurface information available at the time. One of the first was by Kesler and was limited to the Kings Mountain and Beaverdam Creek areas. Including only the larger pegmatites and restricting their depths to 100 feet, he estimated reserves in these areas to be about 4,325,000 tons of mineable ore, averaging 15 per cent spodumene. By using 7 per cent as the average lithia (Li_2O) content of the spodumene, he calculated the ore reserve to contain about 45,500 tons or 4,550,000 units of lithia. These figures were compiled prior to any appreciable subsurface exploration and are conservative.

Griffiths made a rough estimate of the total spodumene resources by assuming one-third of all pegmatite material throughout the belt, calculated at 66,000,000 tons to a depth of 300 feet, to contain 10 per cent spodumene. This represents 6,600,000 tons of spodumene, or about 48,000,000 units of lithia.

Lithia reserves for the United States were compiled by Norton. For the entire belt, he estimated the indicated reserve of 1.7 per cent ore to a depth of 400 feet to be 4,000,000 units. By lowering the grade of ore to 1.3 per cent lithia and extending the deposits to a depth of 450 feet, he estimated the inferred reserve at 124,000,000 units. Indicated and inferred reserves totaled 128,000,000 units.

Present Estimate: In calculating reserves for this report, an attempt was made to include only those pegmatites which appeared to be most favorable for development. Outcrop areas were measured by pacing. The following limiting factors were used in preparing the estimate:

Minimum horizontal dimension of dikes	10'x200'
Weight-volume ratio	1 short ton = 12 cu ft
Depth . . varies with dike	(maximum) 300'
Spodumene content (minimum)	15%
Li_2O content of spodumene	7.3%

Final reserve figures were calculated after an inspection of major outcrop areas and consultation with geologists, mining engineers, and drillers familiar with the pegmatite occurrences.

Reserves of spodumene ore which appear favorable for mining are estimated at 41,500,000 short tons for the entire tin-spodumene belt. Much of it will average 1.25 per cent lithia, and a considerable portion will range between 1.3 per cent and 1.6 per cent. The distribution by areas of reserves of lithium ore in the tin-spodumene belt in North Carolina is presented below. No attempt was made to differentiate between weathered and unweathered pegmatite rock. In many of the dikes from 15 per cent to 30 per cent of the first 100 feet is weathered sufficiently to affect the grade of ore.

Area	Pegmatite Ore (short tons)	Spodumene (short tons)	Lithia (units)
Kings Mountain	22,900,000	4,250,000	31,050,000
Long Creek	10,500,000	1,795,000	13,100,000
Beaverdam Creek	3,000,000	545,000	3,980,000
Lincolnton	5,100,000	945,000	6,900,000
TOTALS	41,500,000	7,535,000	55,030,000

The reserves listed above do not represent the total amount of spodumene in the tin-spodumene belt. Large volumes are present in the hundreds of small pegmatites which abound throughout the belt, but economic recovery of such material is yet to be proved. Undoubtedly, there are sizable tonnages of ore below the limiting depth of 300 feet, and as mining progresses much of it will be recovered.

Future Outlook: Estimated reserves of readily recoverable lithium ore in the tin-spodumene belt are sufficient to maintain the current rate of production for more than seventy-five years. The reserve estimates are conservative and are expected to increase as development work advances. In its annual report for 1955, Foote Mineral Company listed its measured and indicated ore reserve at 23,985,506 tons, or enough to operate at present levels for at least fifty years. Lithium Corporation of America's reserves assure that company of an extended period of operation. Additional proved ore indicates that the tin-spodumene belt is capable of supporting increased production facilities if the present demand for lithium continues. A major drop in price would make many of the smaller deposits now considered as workable uneconomical to develop.

The large volume of high-grade ore, location with respect to markets, and accessibility for mining and milling make the spodumene deposits in North Carolina the most important single source of lithium in the United States. These deposits are in a highly favorable economic position. Their location and quality assure the United States of a well protected major source of lithium.

Bulldozer working in blocky ore at Kings Mountain, N. C., open pit.

It is interesting to note that Hess and Ralston, of the U. S. Bureau of Mines, explored this district during 1930 to 1940, limiting their work to surface showings, and predicted a reserve of approximately 100 million tons of spodumene ore, averaging something less than 1 pct Li_2O. Recent exploration in this area closely substantiates this early report.

centrates can be shipped because of the costs of transportation.

It is certain that whatever concentrates are produced in Canada, Africa, or points some distance from the mines, the unit cost of Li_2O will be high, and with attendant losses in the extraction plant, a high unit cost of raw materials will be reflected in the end products. Such raw material costs would be 25¢ to 40¢ per lb lithium carbonate or equivalent.

Growth of the Lithium Industry: Table I, the compilation published by the USBM, shows an annual consumption of lithium products in the U. S. in 1935 to 1939 of approximately 300,000 lb (as lithium carbonate). It is estimated that in 1956 production will exceed 30 million lb, roughly 100 times the consumption 20 years earlier.

What can be expected for the next ten years? Ordinarily an annual increase of 4 to 8 pct could be anticipated. To widen the use of lithium products substantially beyond present uses, costs of production must be greatly decreased. Considerations basic to this requirement may be summed up as follows:

1) Adequate reserves of lithium minerals that are of mineable quality and well located.

2) Better methods of winning lithium from its ores than the conventional methods now in use.

3) Operations on a large enough scale to permit lowest costs, e.g., the mining and treatment of 1000 tons per 24 hr.

Table II shows approximate capacity of the four producing companies in the U. S. in terms of lithium carbonate or its equivalent. In the past ten years this has been expanded about ten times.

Consumption of Lithium Products: In Table III estimated figures on total consumption are broken down to show consumption for specific uses or industries. Exact figures are not reported or not available on industrial uses, and quantities for defense requirements are usually classified information. However, the figures presented indicate the distribution of these products.

It is reasonable to expect that demonstrated industrial uses will continue to increase as the industries expand. A vast amount of research will generate further uses. Predictions on market increases are hazardous, but during the next few years industrial demand in the U. S. should approximate the present available capacity. Accordingly, if defense requirements continue or increase, there will be a need for increased production capacity within the next five years.

Lithium developments were advanced by the demands of modern warfare. World War I saw the start of commercial development. World War II offered a much wider horizon, and in the past decade there have been startling developments in application. Up to this time, lithium products had been used in fields where the unique properties of lithium made it interesting in spite of its relatively high cost. In most present applications, lithium metal or lithium compounds are used in minor quantities in the manufacture of other products. Here again, the cost of lithium materials is not a major factor.

Sooner or later it must be recognized that other possible fields of application do not fall in these stated categories. Then lithium must compete with other materials in cost or application to be of interest, and in such cases quantity requirements will be large as compared with present consumption.

Although this discussion is concerned chiefly with the growing demand for the element lithium, some

At top: Flotation beneficiation of spodumene ore yields concentrates as high as 6 pct Li_2O from 1½ pct ore. Above: Stockpile of ore at Foote's Kings Mountain operation carries up to 15 pct spodumene.

Table I. Growth of the Lithium Industry in the U. S.

Year	Li_2CO_3 (or Equivalent), Lb
1935 through 1939 (average)	290,000
1940	370,000
1941	680,000
1942	980,000
1943	1,520,000
1944	2,790,000
1945	900,000
1946	1,060,000
1947	650,000
1948	960,000
1949	1,360,000
1950	2,430,000
1951	3,020,000
1952	4,100,000
1953	5,800,000
1954	9,000,000
1955	15,000,000
1956	Over 30,000,000

These figures up to 1955 were published by the U. S. Bureau of Mines. They represent the amount of lithium carbonate equivalent in the raw material mined, applying a factor of 66 pct recovery of finished product. While the fact is not shown, many of the earlier figures may not be accurate, as some mined material has been used directly, e.g., lepidolite or petalite in special glass manufacture.

Table II. U. S. Production Capacity of Lithium Carbonate or Its Equivalent in Thousands of Pounds Annually

Company	1946	July 1952	September 1954	1955	1956
Maywood Chemical Works	1,000	1,000	1,300	1,300	1,500
Lithium Corp. of America Inc.	3,000	3,000	3,000*	13,000	21,000†
Foote Mineral Co.	0	725	6,000	12,000**	12,000
American Potash & Chemical Corp. (inc. American Lithium Corp.)	0	1,175	1,500	1,700	7,700‡
Total—U.S.A.		5,900	11,800	28,000	42,200

* Prior to operation of plant at Bessemer City, N. C.
** Appears to be in excess of quantities of ore mined at Kings Mountain, N. C., and used in chemical plant at Sunbright, Va.
† Reflects potential capacity at Bessemer City, using concentrates instead of low grade ore.
‡ This figure includes data for plant at San Antonio, Tex. Earlier figures represent recoveries from brine recovery at Trona, Calif. The total figure is estimated and may be more or less as determined in actual full-scale operations.

Table III. U. S. Consumption of Lithium Carbonate or Its Equivalent

Use	(Li_2CO_3, in Thousands of Pounds) 1951, Estimated*	Pct	1955, Estimated**	Pct	1956, Estimated	Pct
Lubricating greases	816	27	3300	39	3500	11
Ceramics	779	26	1600	19	5000	15.7
Aluminum welding and brazing	287	9	1100	13	1520	4.7
Air conditioning	320	11	1100	13	1100	3.4
Batteries, primary and secondary	393	13	610	7	600	1.9
Pharmaceuticals	33	1	30	—	250	0.7
Metallurgical	not given	—	not given	—	30	0.1
Defense and miscellaneous	393	13	760	9	over 20,000	62.5
	3021	100	8500	100	00	100.0

* *Chemical Week*, Nov. 8, 1952 (Year 1951).
** Actual figures for the year 1955 for industrial consumption are probably more than 9 million lb total lithium carbonate or its equivalent. Actual figures are not available. The difference is allocated to "defense and miscellaneous."

Table IV. Consumption of Lithium Metal

Year	Pounds Per Year
Prior to 1914	Experimental lots for research
World production, 1914 to 1942	Less than 5,000
U. S., 1942 to 1946	Less than 100,000
U. S., 1947 to 1952	Less than 30,000
U. S., 1955, estimated	More than 100,000
U. S., 1956, estimated	More than 200,000
U. S., 1957, estimated	More than 300,000
Potential demand	1,000,000 ±

reference should be made to the growth of lithium metal consumption, given in Table IV.

Lithium metal is used in a variety of industries, e.g., synthetic vitamins, antihistamines, and organic syntheses including promising application in rubber and petrochemical processes.

In metallurgy, lithium metal is used as a scavenger and degasifier, particularly in the nonferrous field. Considerable work has been done in the field of light metals, particularly lithium-magnesium alloy of high strength and low density. Alloys containing lithium are finding excellent use in brazing operations, and lithium metal has more than likely possibilities in the improvement of alloy and specialty steels.

Brief Review of Recovery Processes: It is not the purpose of this article to go into various ramifications of the winning of lithium, but a few significant factors become a part of the thesis of lithium industry growth.

The critical problem is extraction of lithium from its ores. The conventional processes are the sulfuric acid method and the lime method. Both require high temperature for decrepitation and subsequent leaching and purification, producing lithium carbonate as the end product in the acid method and lithium hydroxide in the lime method. The acid method is applied to low grade ores or concentrates and the lime method to concentrates. The lime method is better suited to the treatment of lepidolite (American Lithium Corp.). In any event the net recovery of lithium products is metallurgically very disappointing:

Acid method:	1 to 1+ pct Li_2O	65 pct
	4 pct Li_2O	80 pct
	5 to 6 pct Li_2O	90 pct
Lime method:	5 to 6 pct Li_2O (spodumene)	
	3 to 3.5 pct Li_2O (lepidolite)	70 pct or better

If the losses in ore concentrating operations are included, then the recoveries from mine to finished product would appear to be as follows:

Acid method:	1 to 1.5 pct Li_2O	65 pct
	4 pct Li_2O	80 pct
	5 to 6 pct Li_2O	85 pct
Lime method:	5 to 6 pct Li_2O	50 pct or better

To reduce costs, therefore, any approach to process improvement must call for a means of increasing the amount of lithium extracted. At the same time, the simplification of plant design and reduction of investment in plant must also be weighed. There must be continued and extended research on recovery methods, as well as product research for new uses.

References

[1] S. D. Broadhurst: Lithium Resources of North Carolina. North Carolina Department of Conservation and Development *Inf. Circ. 15*, 1956.
[2] J. J. Norton and D. M. Schlegel: Lithium Resources of North America. *USGS M.R. Bull. 1027*, 1955.
[3] J. C. Arundale: Lithium (Chapter on Mineral Facts and Problems). *USBM Bull. 556*, 1953.
[4] J. C. Arundale: Chapter on Lithium, *USBM Yearbook*, 1953.
[5] D. P. Eigo et al.: Lithium. *Engineering and Mining Journal*, September 1955, pp. 75-89.
[6] P. E. Landolt: Lithium Minerals Provide Unique Industrial Raw Materials. MINING ENGINEERING, December 1951.
[7] G. A. Munson and F. F. Clarke: Mining and Concentrating Spodumene in the Black Hills, South Dakota. *AIME Trans.*, 1955, vol. 202, pp. 1041-1045.
[8] R. S. Ellestad and F. F. Clarke: Extraction of Lithium from Its Ores. *AIME Trans.*, 1955, vol. 202, pp. 1045-1047.
[9] F. Hess: *Lithium*, pp. 76-89. F.C. 7054, February 1940.
[10] P. E. Landolt: The Lithium Industry. *Journal of the Electrochemical Society*, December 1955.
[11] P. E. Landolt: Lithium. *Rare Metals Handbook*, 1954.

aime news

Society of Mining Engineers Names Officers and Committeemen

At the New Orleans AIME Annual Meeting the Society of Mining Engineers was activated as one of three societies within the new overall AIME structure. Under Society President Elmer A. Jones the group is rapidly completing the initial slate of officers and has already gotten operations underway. An outline of Society structure, together with organization charts of both the Society, and of AIME appeared in the February issue of MINING ENGINEERING, pages 264-268.

At the first meeting of the Society Board, February 28, it was decided that the Nominating Committee listed below would serve until 1958. Other terms of office, unless otherwise noted, are until 1958.

(Data as of March 15, 1957)

Officers

President: Elmer A. Jones
Past-President: Will Mitchell, Jr.
Regional Vice-President: (3 to be elected)
Treasurer: R. B. Ladoo
Secretary: Arnold Buzzalini

Board of Directors

(President, Past-President, President-Elect, Regional Vice Presidents [3], Treasurer)

Three-Year Terms

H. C. Weed—Mining
J. D. Forrester—Geology
J. W. Woomer—Coal Div.
R. M. Grogan—IndMD
D. W. Scott—MBD

Two-Year Terms

Gill Montgomery—Mining
H. V. W. Donohoo—Geophysics
C. T. Holland—Coal Div.
T. L. Kesler—IndMD
E. H. Crabtree, Jr.—MBD

One-Year Terms

R. D. Longyear—Mining
G. D. Emigh—Geology
C. T. Hayden—Coal Div.
R. B. Ladoo—IndMD
R. E. Byler—MBD

Nominating Committee

(President, Past-President)

Members

H. A. Krueger—Mining (Chairman)
R. F. Moe—Mining
D. M. Fraser—Geology
Wayne Dowdey—MBD
J. C. Lokken—MBD
R. M. Tripp—Geophysics
J. C. Gray—Coal
G. R. Spindler—Coal
A. B. Cummins—IndMD
R. M. Foose—IndMD

Alternates

R. H. Feierabend—Mining
J. A. Mecia—Mining
H. R. Gault—Geology
H. L. Scharon—Geophysics
J. A. Hagy—Coal Div.
D. R. Mitchell—Coal Div.
S. D. Michaelson—MBD
N. L. Weiss—MBD
R. C. Stephenson—IndMD
G. H. Chambers—IndMD

Editorial Board

Chairman: H. C. Weed
D. W. Scott
J. W. Woomer
A. Buzzalini
R. B. Ladoo
R. A. Beals—MINING ENGINEERING Advertising Director

Transactions Editorial Committee

Chairman: H. C. Weed
D. R. Irving—IndMD
C. D. Smith—MGGD
S. F. Ravitz—MBD
S. P. Wimpfen—Coal Div.
R. A. Beals—MINING ENGINEERING

General Editorial Committee

Chairman: D. W. Scott
Brower Dellinger—MGGD
R. C. Stephenson—IndMD
R. H. Ramsey—MBD
R. T. Gallagher—Coal Div.
R. A. Beals—MINING ENGINEERING

Advertising Committee

Chairman: J. W. Woomer
Advertising Director
R. A. Beals—MINING ENGINEERING
W. L. Wearly
(Two members at-large, to be appointed)

Admissions Committee

Chairman: Robert M. Grogan
F. A. Ayer—MGGD
J. C. Fox—MGGD
F. W. McQuiston, Jr.—MBD
J. P. Bonardi—MBD
A. C. Brinker—Coal Div.
L. P. Warriner—IndMD
J. B. Graham—IndMD
G. R. Spindler—Coal Div.

Program Committee

Chairman: Gill Montgomery
N. Arbiter—MBD
T. E. Gillingham, Jr.—IndMD
R. H. Feierabend—MGGD
G. L. Judy—Coal Div.

Membership Committee

Chairman: Hugo Johnson
Contact Director: E. H. Crabtree, Jr.
Lucien Eaton—MBD
M. D. Lagrange, Jr.—MGGD
H. A. Meyerhoff—IndMD
G. R. Spindler—Coal Div.

Executive and Finance Committee

President: Elmer A. Jones
Treasurer: R. B. Ladoo
(Three to be named)

Minerals Economics Committee

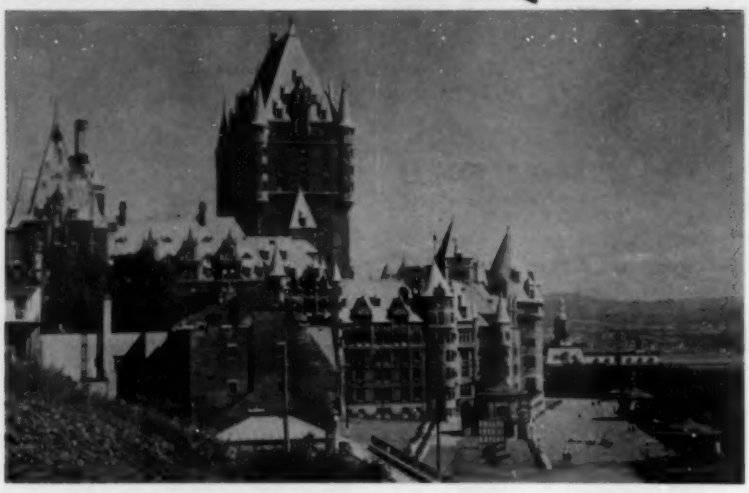
Chairman: L. C. Raymond
E. H. Rose—MBD
R. B. Ladoo—IndMD
M. E. Volin—MGGD
J. J. Schanz, Jr.—Coal Div.

Education Committee

Chairman: E. P. Pfleider
M. E. Wadsworth—MBD
M. D. Cooper—Coal Div.
S. C. Cole—IndMD
T. H. Kuhn—MGGD

Note: Not all appointments had yet been approved, not all acceptances had yet been received at press time. Any revisions and corrections will appear in the May issue of MINING ENGINEERING.

Schedule Fuels Conference at Quebec



The 20th Annual Joint Solid Fuels Conference sponsored by AIME and ASME in cooperation with the CIM Coal Div. has been scheduled for Oct. 10-11, 1957 in Quebec, Canada. Headquarters for the meeting will be the Chateau Frontenac. This year the theme is *Coal-Energy Reservoir of North America.*

Reno Site of Mineral Industry Conference

Co-sponsored by AIME Local Sections in Nevada, Southern California, and San Francisco, the First Pacific Southwest Mineral Industry Conference is slated to be held in Reno on April 5 and 6.

In addition to four technical sessions the first day, two field trips are planned for April 6. One will be to Eagle-Picher Co., and to the open pit gypsum mine and board plant of U. S. Gypsum Co. The second trip will take participants to Anaconda Co.'s copper mine and plant at Weed Heights. A full schedule of social events includes a cocktail party and dinner, while the ladies have a treat in store for them in the form of a smorgasbord luncheon.

International Mineral Dressing Congress to Be Held Sept. in Sweden

Stockholm will be the site of the International Mineral Dressing Congress scheduled for September 18 to 21. The official languages of the Congress will be English, French, and German with simultaneous interpretation of all lectures and discussions in the three languages. Preprints of the papers, as well as the final report of the Congress, will be printed in English.

About 25 papers will be presented and discussed within the following groups of subjects: mineral structure and comminution, classification and gravity separation, magnetic concentration, roasting and sintering of iron ores, flotation, mineral processing by chemical methods, and treatment of uranium ores. Technical sessions will be held at the Royal Institute of Technology, and the premises of the Students' Assn. have been offered for meals and relaxation.

From September 22 to 26, excursions to mining districts in Central and North Sweden, Norway, and Finland have been arranged.

The official opening will take place in the Stockholm Concert Hall, and a banquet and dance will be held in the Town Hall. In addition, a special ladies' program has been planned. For information and reservations write to: The General Secretary, International Mineral Dressing Congress, Nackstromsgatan 1, Stockholm C, Sweden.

N. Y. Section Adds To Scholarship Fund

The AIME Executive Committee has approved the transfer of $3000 from the funds of the New York Section to the educational fund of the Woman's Auxiliary of the Institute. The money will provide for one New York Section Scholarship for undergraduate study in any field covered by the mining, metals or petroleum branches of AIME. The scholarship will be awarded for use at any college or university granting degrees in these fields if the curriculum leads to the degree and has the approval of the Engineers' Council for Professional Development.

The recipient is to be selected by the WAAIME, from those applying from any of the 48 states.

Pacific Northwest Regional Conference

Portland, Ore., will play host to the AIME 1957 Pacific Northwest Regional Conference to be held in the Multnomah Hotel, April 11 to 13. Among the outstanding speakers scheduled to address the conferees, is AIME President-Elect A. B. Kinzel, vice president in charge of research at Union Carbide & Carbon Corp. He will be heard at the banquet on Friday, April 12, on the subject of *Research in the New Metallurgy.*

The two field trips on the agenda include a visit to the Oregon Metallurgical Corp., the Bureau of Mines, and a tour of the Portland Owens-Illinois Glass Plant.

Those attending will have an opportunity for socializing at the cocktail party and banquet in the Grand Ballroom of the Multnomah Hotel.

United Engineering Center Fund Drive Begins

The new United Engineering Center sponsored by AIME, AIChE, ASME, ASCE, and AIEE, to foster unity throughout the engineering profession, receives its first contribution in a drive to collect the estimated $10 million needed for the building, scheduled for completion by 1959 in a midtown New York location. J. F. Lawrence, chairman, N. Y. Section, AIChE, is shown presenting a $500 check from his section to W. J. Barrett, UET president. Also on hand are T. M. Jackson, Jr., far left; and W. F. Thompson, chairman, UET Real Estate Committee, extreme right.

AIME Officers Installed

Dr. Augustus B. Kinzel of New York was installed as AIME president-Elect, at the Annual Meeting in New Orleans. He will serve as president beginning February 1958. Grover J. Holt, of Ishpeming, Mich., general manager of the ore mining department, The Cleveland-Cliffs Iron Co., became President in 1957.

Dr. Kinzel, vice president in charge of research, Union Carbide & Carbon Corp., was born in New York.

He received a B.A. degree cum laude in math from Columbia University, a B.S. in engineering from MIT, and the degrees of Doctor of Metallurgical Engineering and D.Sc. from the University of Nancy in France. New York University awarded him an honorary Doctor of Engineering degree. Dr. Kinzel has

AUGUSTUS B. KINZEL

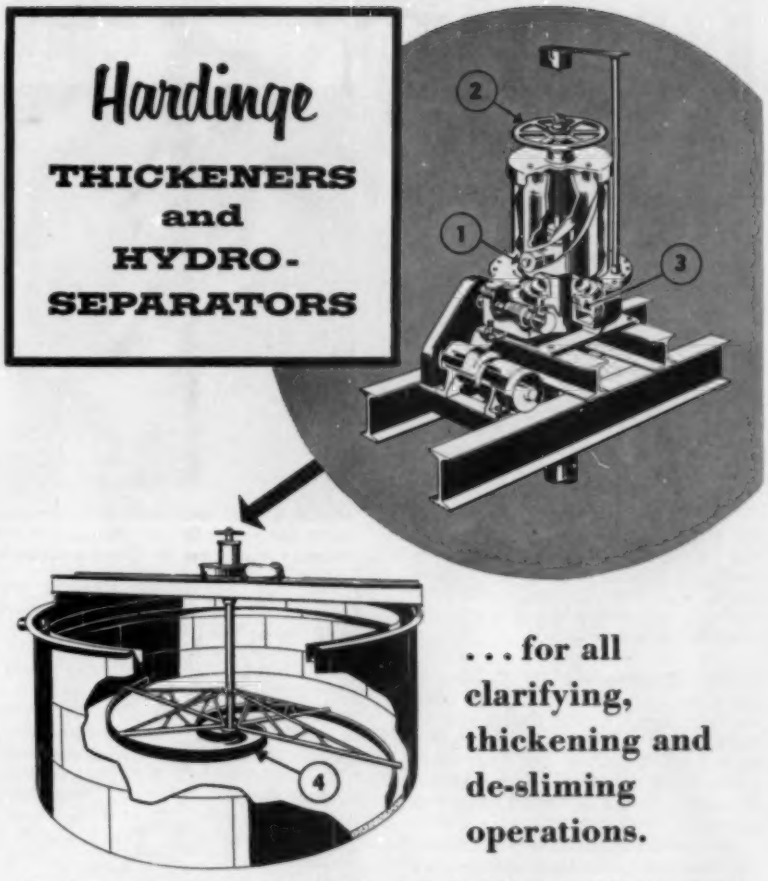
been actively engaged in research with Union Carbide for the past 29 years, and his contributions cover a wide range of activities in the fields of metallurgy, industrial gases, and atomic energy. He pioneered in the theory of stainless steels, was responsible for solving difficulties in the welding and cutting of steel, and has more than 40 patents issued in his name.

Dr. Kinzel has served as consultant to various AEC installations including Los Alamos, Oak Ridge, Argonne, Knolls Atomic Power, and Brookhaven Laboratories. As a member of the Manhattan District Committee for World Control of Atomic Energy, he helped draft the report that was the working basis for the Lillienthal and Baruch plans.

Co-author of the Engineering Foundation's volumes on low and high-chromium alloys, Dr. Kinzel has also written more than 60 technical papers on metallurgy and physical chemistry of steelmaking, on ferro-alloys, testing and welding of metals, and on applied mechanics. An accomplished linguist, Dr. Kinzel has lectured in many countries abroad.

Hardinge

THICKENERS and HYDRO-SEPARATORS

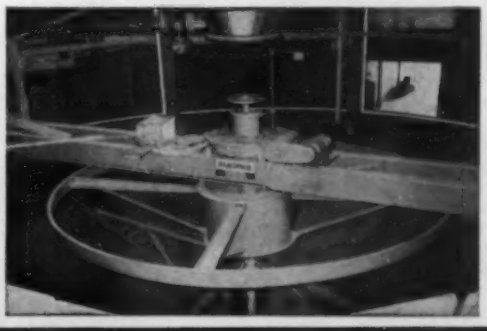


. . . for all clarifying, thickening and de-sliming operations.

For flotation concentrates thickening ahead of filtering—or for tailings disposal or reclamation, Hardinge Thickeners provide:

1. "Auto-Raise" to avoid lost production from overloads.
2. Manual or power raise to supplement "Auto-Raise."
3. Replaceable ring-type ball bearing support for rotating mechanism.
4. Spiral rakes for maximum underflow density.

Also available are froth rakes for froth-free overflow and superposed type tank construction for minimum floor space and building economy. Complete specifications on request. Bulletin 31-E-2.



A 35'-diameter Hardinge Superposed Thickener installation in a Canadian lead-zinc concentrator. The sludge outlet for the upper unit can be seen at the top of the picture. Note froth ring on lower unit.

HARDINGE COMPANY, INCORPORATED

YORK, PENNSYLVANIA • 240 Arch St. • Main Office and Works

New York • Toronto • Chicago • Hibbing • Houston • Salt Lake City • San Francisco

Around the Sections

• The Woman's Auxiliary of the **Chicago Section** held their annual dinner-dance at the Shoreland Hotel, January 26. A record attendance of 230 attested to the success of the affair organized by Mrs. Alex Jolley and her committee.

On February 6, the Section met at the Chicago Bar Assn., the new chairman, Michael Tennenbaum, of Inland Steel Co., presiding. Featured speaker of the evening was Frank M. Richmond of Universal-Cyclops Steel Corp. who presented an interesting paper on the current production of vacuum melted steel, particularly the superalloy steels and high alloy materials. Mr. Richmond pointed out that vacuum melting affords a greater insight into the effect of trace elements on the physical values of the metals produced. This is primarily true with the effects of gases and alloying elements such as boron, zirconium, and titanium. Audience interest was high, and a lively discussion period followed.

• The **Washington, D. C.** Section gave their 31st Annual Oyster Party on February 5, at the National Press Club. There were all the oysters they could eat—on the half shell, panned and fried, and oyster stew—all tasty enough to "satisfy the most particular palate."

No formal speaker was scheduled but several members gave short talks on their trips to faraway spots. Clarence Fredell started the ball rolling with an account of his recent visit to a large manganese deposit in Brazil.

The Section met again at Hotel Willard on February 20, Engineer's & Architects' Day. Keynote speaker for the luncheon was Eric Walker, president of The Pennsylvania State University. At this meeting, awards were presented to outstanding young local scientists and engineers.

• Edward L. Pine, Associated General Contractors of America, addressed the engineers and guests at the regular meeting of the **Reno Subsection** on February 8, in the Nevada Room of the Hotel Mapes. He discussed the recent Reno blasts and fire, and the history of floods on the Truckee River, with special emphasis on the Reno floods of 1950 and 1955. In conclusion, Mr. Pine outlined his recommendations for improvement of the Truckee River Channel and bridges in Reno.

Edmund F. Lawrence, mining geologist of the Nevada Bureau of Mines was selected as vice chairman of the Reno Subsection to succeed H. P. Ehrlinger, III, who resigned to accept a position with the American Smelting & Refining Co. at El Paso.

Mirth and merriment were the order of the day at the Annual Dinner-Dance held by the Woman's Auxiliary of the Chicago Section, in the Shoreland Hotel.

• The **Ajo Subsection** meeting on January 10 at the Copper Coffee Shop, Ajo, Ariz., featured a talk by G. H. Roseveare, metallurgist with the USBM in Tucson. He explained Fluo-Solids roasting experiments being conducted at the University of Arizona Testing Laboratory. The speaker's informative talk generated a lively discussion. A report on the Arizona Section Meeting, December 3, was then given by various members who attended: Frank Denny, Ralph Herndon, Troy Hinton, Bob West, and Jim Littrell.

The Subsection met again on February 14, at the Copper Coffee Shop. Two guests were introduced: Thomas E. Diehl and Frank Galloway, both of Phelps Dodge Corp. After dinner the group watched a showing of the film, *This Is Mi Vida*, which answered many questions about uranium mining operations in Colorado plateau.

• The **Yavapi Subsection** met at the Hassayampa Hotel in Prescott, Ariz., on January 31, to welcome five mining engineers from Spain who are visiting this country as guests of the U. S. State Dept. These visiting engineers were entertained by a cocktail party and a semiformal dinner. They were: Indalecio Gorrocharequi, Alberto Sanchez, Rafael Monetro, Juan de Lizaur, and Lois del Campo. Other guests welcomed at the meeting were Thomas Bardon, president, Shattuck Denn Mining Corp.; Thomas Newell, of the same company; and William Zilbersher of Ventures Ltd. The meeting was presided over by the newly elected chairman, David Lowell.

• At the dinner-meeting of the **Colorado Section** on February 21, at the University Club in Golden, the featured speaker was Fred Mace. In addition to his talk on *Operation Egypt*, Mr. Mace presented a film made by Kerr-McGee Oil Industries Inc., entitled *Through Suez For Oil.*

• The **Boston Section** was honored by the presence of Norbert Weiner as guest speaker at their dinner-meeting February 4, in the MIT Faculty Club. Dr. Weiner, Prof. of Mathematics at MIT, is internationally known for his contributions to mathematical theory and has written a book on cybernetics, the comparative study of the human brain and the electronic brain. His autobiography, published recently was entitled *Ex-Prodigy.* Dr. Weiner addressed the Section on the subject of *The Nervous System and the Control Machine.*

• The **Black Hills Section** has announced the committees for 1957, appointed by chairman Alexander McHugh at the Section meeting on January 10. They are as follows: Paul Gries, student director; Edward Jacobson, chairman, and Paul Anderson, membership committee; Roger Madsen, chairman, and A. L. Lindgard, and R. Keith Collins, program committee.

• The **Southeast Section's** Coffee and Doughnut Session was held on February 11, at the Thomas Jefferson Hotel in Birmingham. At that time, members heard a talk by James R. Cudworth, Dean, College of Engineering, University of Alabama. His topic was *The Status of Engineering Education.*

• The **El Paso Metals Section** met at Hotel Cortez on February 13, to hear Charles Steen, President, Utex Mining Corp., Moab, Utah. After being introduced by Marion S. Bell, Section chairman, Mr. Steen discussed uranium mining. His talk was followed by a film, *This is Mi Vida.*

Divisional Directory

The new Industrial Minerals Div. members directory is available to those who are not members of the division for $1.00 per copy. Send your dollar bill direct to

Industrial Minerals Directory
c/o AIME Business Office
29 W. 39th Street
New York 18, N. Y.

TAKE TIME FOR TAMPA

Advance plans for the Southeastern States Mining Conference:

1. 1000-1500 registrants expected
2. 45-50 papers on sessions
3. Field Trips
4. Deep Sea Mining Tour

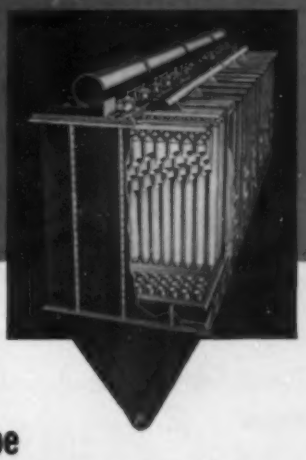
Technical Sessions will cover exploration—mining—beneficiation—industrial minerals—mineral economics. Topics range from copper to cement.

• • •

Prizes for advance registrants.

Dust and Fume Collection by Norblo

helps you achieve efficiency and cleanliness in your plant



Norblo has developed bag type dust collection systems to a high degree of efficiency.

Norblo Automatic Bag Type

For continuous and heavy duty service at constant capacity and efficiency, Norblo Automatic Bag Type collection pays its own way — in recovery of valuable materials or removal of injurious or "nuisance" industrial air contaminants. Norblo builds the entire installation, from blowers to bag-cleaning mechanisms. Complete systems are engineered to meet specific situations. Norblo engineering insures low maintenance and no shut-downs — guarantees performance of every installation.

Norblo Standard Bag Type Collectors

Based on the same construction principles, the standard bag type collectors provide at low cost the high efficiency service that is obtainable only from bag-type cloth filtering, with either compressed air or electrically driven periodical bag shaking and cleaning. Units must be shut down for cleaning — at such times as the noon hour and end of working day.

Norblo Portable Type

For excellent results in localized dust control, Norblo Portables protect equipment and reduce maintenance in grinding, polishing and cutting departments. Six models cover capacities from 300 to 1350 cfm., at 8" static pressure at the fan. Occupy small space. Are unusually quiet.

Write for bulletins describing Norblo bag type dust collectors.

The Northern Blower Company
6424 Barberton Ave., Cleveland 2, Ohio • OLympic 1-1300

Norblo ENGINEERED DUST COLLECTION SYSTEMS FOR ALL INDUSTRIES

Important Notice!

Send Coupon For New AIME Directory

During the month of June, a new all-Institute Directory will be issued. This publication will contain an alphabetical and geographical-company listing of all members on the Institute records, Feb. 1, 1957.

The Directory will be mailed only to those members in good standing who request it by filling out and mailing the coupon below. Each request for the Directory must be made with the coupon. Subsequent announcements will be made concerning the Directory, but the coupon appearing in this issue of the magazine will be the only valid requisition for the book. Fill in the coupon and mail to AIME, 29 West 39th St., New York 18, N. Y.

PLEASE PRINT YOUR NAME AND ADDRESS CLEARLY. THIS COUPON WILL SERVE AS THE ADDRESS LABEL FOR YOUR COPY OF THE DIRECTORY.

Use This Coupon To Order Your AIME Directory

Send 1957 Directory to:

City..... State.....

Street Address.....

Name.....

(Print Name and Address Clearly)

PERSONALS

Victor C. De Munck, formerly with the Montana Bureau of Mines & Geology in Butte, Mont., is now with Kaiser Aluminum & Chemical Corp., Oakland, Calif.

John C. Cosgrove, Jr., has been promoted from sales engineer to assistant district manager, Goodman Mfg. Co., Huntington, W. Va.

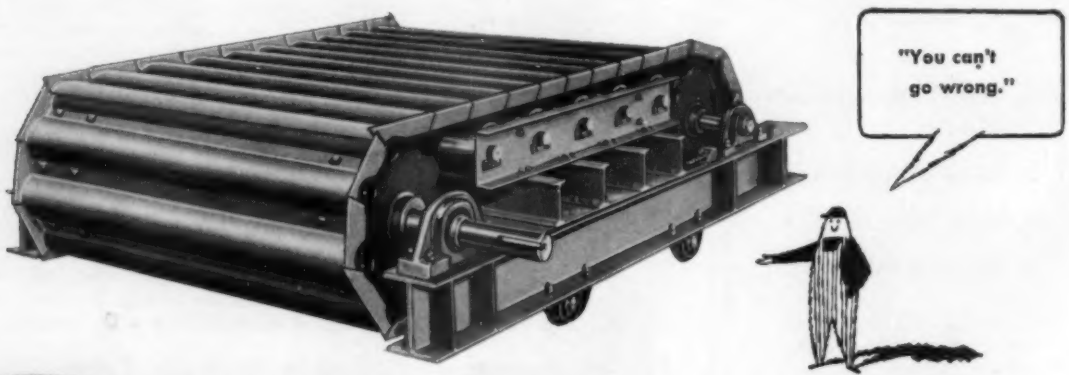
F. J. Clawson has transferred from Bartow, Fla., to the Chicago office, International Minerals & Chemical Corp.

Robert G. Dickinson has completed his military service and is now with The Anaconda Co.'s Darwin Mines Unit, Darwin, California.

Charles M. Hillery has accepted a position with Clyde E. Williams & Associates Inc., professional engineers, Indianapolis.

Francis T. Heuring is working as a geophysicist for the New Jersey Zinc Co., Palmerton, Pa. He had been in Washington, D. C., with the U. S. Hydrographic Office.

K. Blazewicz has concluded his work at Bisichi Tin Co. in Nigeria and is now metallurgist for St. Patrick's Copper Mines Ltd. in Ireland.



REX®

APRON FEEDERS

...performance plus in a package

This Rex Heavy-Duty Feeder is built for your rough, tough service—usually the feeding of coarse materials from bins. The load is carried on large-diameter rollers; all the chain has to do is pull. Power requirements are low, and so is maintenance.

Every part of a Rex Feeder is designed to meet your toughest feeding requirements. Rugged frames, rugged components and husky engineering design are combined to give you long life with minimum down time. For feeders, elevators, idlers, pulleys, see your CHAIN Belt Sales Engineer. CHAIN Belt Company, 4794 West Greenfield Avenue, Milwaukee 1, Wisconsin.

CHAIN BELT COMPANY

Milwaukee 1, Wisconsin

G. W. W. Thomas has accepted the position of mine foreman with Benguet Consolidated Inc., Baguio, P. I.

A. L. Moore has left Kaiser Bauxite Co. in Jamaica, B.W.I., for Kaiser Aluminio Ltda., Belem, Para, Brazil.

E. D. TIERNEY

At The Anaconda Co. the following personnel changes were recently announced: **Edward D. Tierney** has been appointed general superintendent, Great Falls Reduction Dept., succeeding the late **Clarence V. Saylor.** Mr. Tierney was formerly general superintendent of plants, Chile Exploration Co., Chuquicamata. **John Suttie,** foreman at the Mountain Con mine, has been made mine superintendent.

J. SUTTIE

Helmut Leidhold has left Argentina for Colombia and a position with Frontino Gold Mines Ltd.

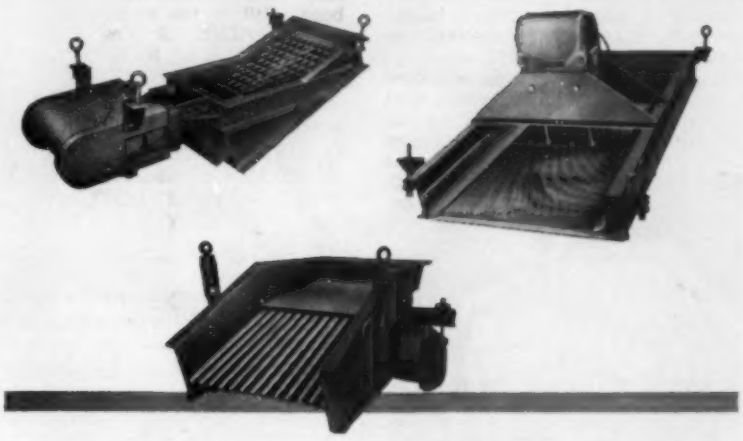
William Crawford has advanced from general manager of the Princess Elkhorn Coal Co. to vice president of The Powellton Coal Co., Mallory, W. Va.

V. Charles Doversberger is now manager of the ABCs Scale Div., McDowell Co., Inc., Cleveland.

(Continued on page 472)

SYNTRON Electromagnetic

VIBRATING SCREENS



for efficient, effective, low-cost screening, and scalping of coal and ores.

Sizing, dewatering, separating, scalping and other process screening necessary to the mining industry—can be accomplished efficiently, effectively and at low cost with Syntron Vibrating Screens.

The unique, instantly controllable vibration of Syntron Vibrating Screens provides a positive screening action, utilizing the entire screening area.

They are compact and functional in design giving more flexibility of installation and keeping moving parts to a minimum for simple, low-cost maintenance. They are sturdily constructed for long dependable service.

Syntron Screening Feeders, Grizzly Bar Screens and Vibrating Screens are powered by Syntron's famous Electromagnetic Drive. Available in single or multiple magnets for higher efficiency, and greater tonnage capacities. Screening surfaces are replaceable.

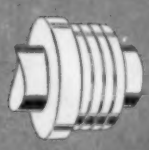
Syntron builds a vibrating screen for every screening problem.

Builders of quality Equipment for more than a Quarter-Century.

Other SYNTRON Equipment of proven Dependable Quality

POWER CONVERSION UNITS

SHAFT SEALS



GASOLINE HAMMER ROCK DRILLS

Write for complete catalog data — FREE

SYNTRON COMPANY
554 Lexington Ave. Homer City, Penna.

Personals

(Continued from page 471)

O. V. Tally has been appointed manager of the Washington district, Allis-Chalmers Manufacturing Co. A member of the firm since 1926, he had been director of industrial sales of the Industries Group.

Alvin S. Cohan, formerly assistant director of public relations and advertising, Titanium Metals Corp. of America, has joined the Public Relations Dept., J. M. Mathes Inc. Mr. Cohan is a former AIME Manager of Publications and editor of JOURNAL OF METALS.

A. S. COHAN

J. H. MELVIN

John H. Melvin, formerly with the Ohio Geological Survey, Ohio State University, is now employed by the Pennsylvania Drilling Co., Pittsburgh.

J. Robert Berg of the University of Wichita in Kansas has been elected president of the Association of Geology Teachers for 1957.

R. H. Paddon is now with Dominion Wabana Ore Ltd., Bell Island, Newfoundland.

Elmer Tveter, head of The Dow Chemical Co.'s Mining and Metallurgical Section, has been transferred to Midland, Mich., from Pittsburg, Calif. Also new to the Midland staff are **Robert Kuchinic,** former research assistant, Pennsylvania State College, and **Harry Moulton,** who was a metallurgist with Continental Uranium Co., Grand Junction, Colo.

Kenneth F. Waggener has been named assistant superintendent of the bessemer converter mill, Youngstown District, Republic Steel Corp. He has been with Republic since 1937.

J. Bruce Hamilton is now on a State Department assignment in New Delhi, India, where he is First Secretary in the U. S. Embassy.

W. W. EVERETT

W. W. Everett is now vice president, Glen Alden Corp., Wilkes-Barre, Pa. Mr. Everett served as co-chairman at the Materials Handling and Safety Sessions during the AIME Meeting in New Orleans.

Anthony Mastrovich is the new general manager of Climax Uranium Co., Grand Junction, Colo., succeeding **Marvin L. Kay.** Prior to his promotion, Mr. Mastrovich was assistant mine superintendent.

J. E. Jerome, former mine engineer with Powell Rouyn Gold Mines, Noranda, Que., Canada, is now employed by Dunany Investments Ltd., Montreal.

P. Böck, onetime employee of the Chile Exploration Co., is now with Tsumeb Corp. Ltd., Tsumeb, South West Africa.

E. R. Swift is now chief production engineer for Mesa Petroleum Co. Inc., Wichita, Kan.

George H. Schenck has terminated his affiliation with *Rock Products* to enter the Graduate School of Industrial Administration at Carnegie Institute of Technology, Pittsburgh.

David M. Middleton has been transferred from Corpus Christi, Texas, to the New Orleans offices of Baroid Div., National Lead Co.

Yes Sir! You'll Save Plenty By Insisting On...

You'll save time because Hoffman Oriented Diamond Bits expose only the hard, sharp cutting edges to the work for faster penetration. They cut rather than scrape to save on power and equipment costs. They assure clean, smooth cores that save the guesswork on formation structures. Available for prompt delivery right to your job site in exactly the size and type you need—Hoffman Bits will also save you plenty of operational headaches.

Write for Literature and Prices—FREE

HOFFMAN BROS. DRILLING CO.

(SINCE 1902)

100 Cedar Street Punxsutawney, Penna.

Personals

(Continued from page 473)

Paul D. Lowman, Jr. has completed his U. S. Army service and is now

Richard F. Down is now assistant mill superintendent for the Tsumeb Corp., Tsumeb, South West Africa.

C. E. Bronson is now with the Cassiar Asbestos Corp. Ltd., Cassiar, B. C., Canada. He had been in charge of his own engineering and surveying practice in Jackson, Calif.

Henry J. Franey, safety engineer for Coker Construction Co., has transferred from Chicago to the company's office in Omaha, Neb.

R. M. Bagenstose is chief engineer for the Jewell Ridge Coal Corp., Tazewell, Va.

V. P. SOKOLOFF

V. P. Sokoloff has been appointed to the faculty of the Dept. of Geology, Columbia University. He had been working in Haifa, Israel.

James N. Harris is now with Gardner-Denver Co., Jackson, Miss.

William A. Miller has joined San Francisco Mines of Mexico Ltd., San Francisco del Oro, Chihuahua, Mexico.

Edwin J. Hodder, Jr., is now employed by Island Creek Coal Co., Holden, W. Va.

Robert Ellingsen, formerly with the Tecan Corp., Massena, N. Y., is now with Merritt, Chapman & Scott Corp., Wickford, R. I.

R. L. Schultze is now assistant general superintendent, Hidden Splendor Mining Co., Grand Junction, Colo.

Major W. Seery has left the Colorado School of Mines for a position with Cerro de Pasco Corp., Mahr Tunnel, Peru.

Tadeusz B. Massalski has concluded his work at the Institute for the Study of Metals, University of Chicago, and is now in the Dept. of Physical Metallurgy, University of Birmingham, England.

(Continued on page 474)

One of the many drill rigs now in operation throughout the United States and overseas.

The most important primary phase of construction, roadbuilding or mining begins with foundation investigation or exploratory work from which it is desired to get complete information and best possible cores. In many instances, contractors make the mistake of bidding on work or taking a contract without complete knowledge of sub-surface conditions, or miners will start mining operations without first conducting a thorough exploration program, but successful contractors and mining men always investigate first to know how to quote in order to get the contract and still make a profit, and how to plan to have a successful operation. One of the most reliable organizations in America for furnishing this information and satisfactory cores is Sprague & Henwood, Inc. For more than seventy years it has been rendering satisfactory core drilling service throughout the United States and the world. Many of its customers have continuing contracts with Sprague & Henwood, Inc., because they know that they can be assured of the best in foundation investigation and core drilling service that can be found anywhere.

Sprague & Henwood, Inc., with its own manufactured field tested drilling equipment; its own manufactured "Oriented" diamond bits; its highly trained personnel; and its well trained and highly qualified supervision assure you of the best possible results obtainable.

Write to Sprague & Henwood, Inc., today for any information relative to test borings or core borings you desire, or for an estimate, giving complete information, and it will be on its way to you just as quickly as possible, without obligation to you.

SPRAGUE & HENWOOD, Inc.
SCRANTON 2, PA.

BRANCH OFFICES: NEW YORK • PHILADELPHIA • PITTSBURGH • ATLANTA
BUCHANS, NEWFOUNDLAND • GRAND JUNCTION, COLORADO

Five AIME members have recently joined the service. **Arlin Deel** and

OBITUARIES

liam S. Kay and Herbert M. Kay; and his mother, Esther Kay, all of

Personals

(Continued from page 473)

Kennecott Copper Corp. recently announced the following appointments: **Robert M. Haldeman,** general manager, Braden Copper Co., has been named vice president, while **Robert G. Woods,** assistant plant engineer, was promoted to general foreman in the leach-precipitation-flotation plant of the Hayden Mill, Ray Mines Div.

C. F. Burt is now with Joy Sullivan Machinery Co. S. A., Mexico City, Mexico.

John M. Girvan has left Cía Minera Aguilar in Argentina to accept a position with Barvue Mines Ltd., Canada.

A. Y. BETHUNE

At the Bunker Hill Co., **A. Y. Bethune** has been promoted to manager of metallurgy, in charge of the company's extensive Kellogg, Idaho, operations. Succeeding Mr. Bethune as zinc plant superintendent is **Walter Schmittroth,** formerly number two man at the operation.

C. R. HUBBARD

Charles R. Hubbard has been appointed to the U. S. Bureau of Mines, Spokane, Wash. He had been associated with the Idaho Bureau of Mines and Geology, University of Idaho.

R. H. Weeks, Jr. is now general sales manager for Thomas A. Edison Inc., W. Orange, N. J., in the Storage Battery Div.

S. H. Glassmire, well known in the mining and nuclear engineering fields, has opened a consulting office in Santa Fe, N. M. With emphasis on rare and strategic ores, Mr. Glassmire's activities will cover southwestern, and also Mexican and South American mineral deposits.

E. G. Malmlow, formerly with Aros Electric Inc., New York, has joined AB Atomenergi, Stockholm, Sweden.

William E. Arndt is with the Eagle-Picher Co., Galena, Ill.

Roland Durocher has transferred from the New York Ore Div. to the Minnesota Ore Div. of Jones & Laughlin Steel Corp.

James J. Scardino has joined Wah Chang Mining Corp., Lincoln Mine Div., Tempiute, Nev.

Paul D. Lowman, Jr. has completed his U. S. Army service and is now enrolled in the University of Colorado as a candidate for the M.S. degree.

John S. Vanderpool is assistant geologist, Christmas Mine Development, Inspiration Consolidated Copper Co., Winkleman, Ariz.

Hugh W. Evans is in the Philippine Islands at Zamboanga Development Corp., Zamboanga City.

Martin D. Kierans has left Cía Minera de Penoles, Monterrey, Mexico, for The Anaconda Co. (Canada) Ltd., Bathurst, N. B., Canada.

C. F. SKINNER

Charles F. Skinner is general manager of Western Machinery Co., San Francisco. He had been manager of the eastern division.

Charles H. Johnson is currently in India on a UN Technical Assistance Administration mission.

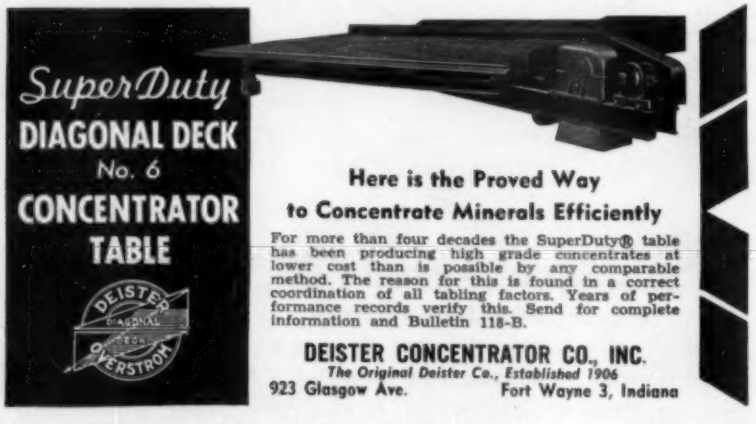
Melvin L. Workman has resigned his position as division manager, Eastern Gas & Fuel Assoc., to become president, Melayne Pocahontas Coal Co., Bluefield, W. Va.

D. H. Lillicrap has joined Alumina Jamaica Ltd., Kirkville Works, B.W.I., as mining engineer.

John D. Stockton has completed his studies at the Colorado School of Mines and is now authorities' engineer for U. S. Gypsum Co., Empire, Nev.

James G. Henderson, whose exploration work with the AEC recently took him to Bolivia, is now assisting in raw materials exploration for the Spanish government.

Leo M. Abell has been appointed concentrator superintendent of the Morenci Branch, Phelps Dodge Corp., succeeding **J. E. Papin** who retired recently. Mr. Abell was formerly research engineer.


SuperDuty
DIAGONAL DECK
No. 6
CONCENTRATOR
TABLE
DEISTER
DIAGONAL
OVERSTROM
Here is the Proved Way
to Concentrate Minerals Efficiently
For more than four decades the SuperDuty® table has been producing high grade concentrates at lower cost than is possible by any comparable method. The reason for this is found in a correct coordination of all tabling factors. Years of performance records verify this. Send for complete information and Bulletin 118-B.
DEISTER CONCENTRATOR CO., INC.
The Original Deister Co., Established 1906
923 Glasgow Ave.
Fort Wayne 3, Indiana

Obituaries

he was in charge of developing properties and supervising underground

Five AIME members have recently joined the service. **Arlin Deel** and **Samuel M. King** are lieutenants in the U. S. Army Corps of Engineers; **Hugh A. Crisp** has begun U. S. Naval Reserve duty in the Civil Engineering Corps, while **David L. Collins** and **Raymond H. Walke** represent the Army and Marine Corps, respectively.

Charles P. Knaebel, former chief engineer, Teekay Mines Inc., Sausalito, Calif., is now employed by the Taylor-Knapp Co.

Armstrong R. Matthews, president of Pocahontas Fuel Co. Inc., Pocahontas, Va., has been elected president of the board of directors, Pittsburgh Consolidation Coal Co.

Ralph E. Magnuson, Jr. has been promoted to the position of chief mining enginer for The Cleveland-Cliffs Iron Co. He will continue to serve as administrative assistant in addition to his responsibilities.

Joseph M. Downey is assistant process engineer with Southwest Potash Corp., Carlsbad, N. M.

William H. Bierschenk has joined General Electric Co.'s Hanford Atomic Products Operation at Richland, Wash., as geologist-hydrologist. He had been associated with the Ground Water Branch, USGS, in Providence.

OBITUARIES

Marvin L. Kay

An Appreciation

by John C. Mitchell

Marvin L. Kay (Member 1953), vice president and general manager of Climax Uranium Co. and active member of the Colorado Plateau Section, passed away at the age of 42 from complications following an emergency abdominal operation. He was born Nov. 6, 1914, at Council Bluffs, Iowa. He died Dec. 7, 1956, at Grand Junction, Colo.

As a student, Marvin attended the public school system of Council Bluffs, Iowa. After graduating from high school in Council Bluffs, he entered Iowa Wesleyan College at Mt. Pleasant, transferring to the Colorado School of Mines where he was president of his class and was named little All-American Tackle in 1939. He received his degree of Engineer of Mines in 1940. He and Mary K. Metzger of Arvada, Colo., were married May 25, 1936. Surviving are his wife; five children, Marvin Kay, Jr., William F., Molly, Kathy, and Betsy; a sister, Mrs. Ellen Kenny; two brothers, Dr. William S. Kay and Herbert M. Kay; and his mother, Esther Kay, all of Corsicana, Texas.

After graduating in 1940, his first employment was with the Alta Mines in Ophir, Colo., where he served and advanced rapidly from engineer to general superintendent within a span of two years. During the war years, 1942 through 1946, he was Supt., Synthetic Cryolite Plant, Aluminum Ore Co. in East St. Louis, Ill. He moved his family to Ouray in 1946, and was manager of the American Zinc Lead Co.'s mines and mill in the San Juan area of Colorado, where he remained until 1951. From 1951 until his untimely death, he was vice president and general manager of Climax Uranium Co., with headquarters in Grand Junction, Colo. During this period he guided and built up the young company into one of the top uranium mining and processing companies.

During Marvin L. Kay's short lifetime, his outstanding organizational and administrative ability had served not only his employers, but also many civil and community organizations as well. A tribute to his unselfishness is the number of organizations in which he was active and to which he devoted much time for the betterment of his community. He was a member of the Lions Club, the Society of Professional Engi-

(Continued on page 476)

The Engineering Societies Library

Over 170,000 volumes covering all branches of engineering in addition to some 1,400 periodicals from all parts of the world are available in the Engineering Societies Library. Bound books may be borrowed by mail by any member of a Founder Society in the continental United States or Canada at prices established in the information pamphlet which is available from the library. Also included in the library's services are searches, translations, and photoprints and microfilm at a nominal cost.

THE ENGINEERING SOCIETIES LIBRARY
33 West 39th Street, New York 18, N. Y.
Mr. Ralph H. Phelps, Director

Please send me information pamphlet, on services available, and their costs.

Name .....

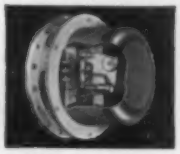
Street .....

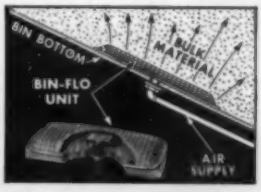
City ..... State .....

NEW BIN LEVEL INDICATOR

New ROTO-BIN-DICATOR®
Motor driven paddle-type bin level indicator
For automatic bin level indication or control of bulk materials. Particularly suited to applications on bins subject to pressure or vacuum.
EXPLOSION-PROOF
U. L. listed units available

BIN-DICATOR®
The original diaphragm-type bin level indicator. In successful use for 20 years.





BIN-FLO®
Assures gravity flow of pulverized materials
Bin-Flo Aerator units in bins, chutes, etc., use small volume, low pressure air to restore flow to dry, pulverized materials which tend to pack and bridge in storage.

THE BIN-DICATOR CO.
13946-G2 Kercheval • Detroit 15, Mich.
Write for detailed literature or call
VAlley 2-6952

WE SELL DIRECT • PHONE ORDERS COLLECT

Ross V. Seeton, Jr., Grand Junction, Colo.
K. P. Singh, Bihar, India

Junior to Member

Obituaries

(Continued from page 475)

neers, the Industrial Council for the State of Colorado, and past-president of the Colorado Mining Assn.

Marvin's capacity to serve in educational and civil matters was great. Perhaps his outstanding trait was his ability to instill confidence in young engineers. He dominated any group or conference he was with, a formidable foe on the one hand and on the other hand, a loyal associate unwilling to expose others to risks which would not have deterred him personally. He was a diligent, tireless, and dedicated worker, whether it was on the job or serving his fellow man or community. His premature death cut short an outstanding career, and without doubt Marvin would have continued to climb to the very top. All of us who were his friends and associates have suffered a great loss in his passing.

Carey S. Allen (Member 1954) died on Sept. 9, 1956. Born in Bedford, Iowa, he received his B.S. degree at South Dakota State School of Mines in 1927. Mr. Allen began his career with Jeffrey Manufacturing Co. in Columbus, Ohio, and resumed his association with that company at various stages of his life, serving as manager of the renewal parts division from 1946 to 1953. At the time of his death he was district manager of the company's operation in Salt Lake City.

Melvin Brugger (Member 1918) died suddenly on June 23, 1956, in Colorado. Born on March 12, 1892, he received a degree in mining engineering from Colorado School of Mines. In 1918, Mr. Brugger joined Selection Trust Ltd., Kosovo, Yugoslavia, and later came to London as manager of mine exploration. In 1948, he made his home in Colorado Springs, Colo., where he established a consulting practice.

John L. Draeger (Member 1935) died on Nov. 5, 1956. Born in La Grange, Ill., on March 11, 1914, he graduated from the University of Arizona with B.S. and M.S. degrees in mining engineering. From miner with Magma Copper Co., Superior, Ariz., he rose to level boss, shift boss, and, in 1947, became special problems engineer. After serving as a 2nd lieutenant during World War II, he became assistant mine superintendent for the Magma Copper Co.

Rudolph Ericson (Member 1914) died recently. Born in Ishpeming, Mich., in 1878, he obtained an engineering degree through correspondence from the University of Chicago in 1896. His early experience included jobs with the Lake Angeline mine at Ishpeming, Jones & Laughlin Ore Co., and Davidson Ore Mining Co. in Iron River. In the latter job he was in charge of developing properties and supervising underground mine construction. In 1925 he became general superintendent, serving until his retirement in 1946.

Charles E. Hough (Member 1942) died recently. A native of Fairmont, W. Va., he was born on July 21, 1905, and studied at Ohio State University and West Virginia University. In 1933 he joined Koppers Coal Co. in Grant Town, W. Va., as chief draftsman, becoming assistant chief engineer in 1938. West Virginia Coal & Coke Corp. employed him as superintendent of mines until 1952, when he became president of Randolph Smokeless Coal Co. He served as president of Norton Coal Co., Norton, W. Va., from 1955 until his death.

John E. Jones (Member 1944) died Sept. 12, 1956. Born in Plains, Pa., on Aug. 1, 1891, Mr. Jones was secretary, Jones Coal Corp., Pittston, Pa., at the time of his death. Prior to that, he had operated Otto Collieries with his brother at Branchdale, Pa. He began as a mine operator at Clifford Colliery, Avoca, Pa.

J. H. Marsman (Member 1934) died last May of a heart ailment. The former president of Marsman & Co. Inc. in Manila, P. I., was born in Amsterdam, Holland, on July 29, 1892. He went to the Dutch East Indies as a chemist and civil engineer in 1916, after which he became general manager of Malabon Sugar Co. in the Philippine Islands. His own company was one of several over which he presided and in which he was a director, including Suyoc Consolidated Mining Co. and Itogon Mining Co. On Dec. 7, 1941, he was captured by the Japanese, but made his escape soon afterward. A book which appeared in 1942, entitled *I Escaped From Hong Kong* was the result of these experiences. His last employment was as civil engineer, Marsman & Co. Inc., San Francisco.

Philip J. McGuire (Member 1951) died recently. A native of Pueblo, Colo., he received his degree in mining engineering from Colorado School of Mines in 1915. He began his career with the Portland Gold Mining Co., Victor, Colo., and in 1919 joined the Dorr Co., Denver, as sales engineer. In 1935, he was employed as manager of the western sales division of Oliver United Filters Inc., San Francisco, and remained there for 16 years. His last position was director of development for Dorr-Oliver Inc. in Oakland, Calif.

Charles W. Plumb (Member 1920) died May 7, 1956 of a heart attack. A native of California, Mr. Plumb joined U. S. Smelting, Refining and Mining Co. in 1909, becoming assistant manager of mines in 1924. From that position, he rose to become general manager of Consolidated Copper & Sulphur Co., Middle Fork Gold Mining Co., and Idarado Mining Co. In 1947, Mr. Plumb opened a consulting office in Sacramento, later joining Central Eureka Mine and the Shasta Co. as consultant engineer.

Robert H. Ridgway (Member 1932) died suddenly on Oct. 26, 1956. Born in Scranton, Pa., on Oct. 14, 1899, he attended the University of Minnesota, earning a degree of engineer of mines. After brief periods as a highway engineer and technical investigator, he joined USBM in 1928 as associate mineral economist. In 1950 he was made chief of the ferrous metals and alloy branch of the minerals division. His last association was with Pittsburgh Metallurgical Co. Inc., Niagara Falls, N. Y.

William B. Senseman (Member 1925) died in April 1956. He was born in Scott City, Kan., and attended Kansas University. In 1911, he began a lifetime association with Raymond Bros. Impact Pulverizer Co. in Los Angeles, becoming manager of the company's western office in 1922.

Henry B. Spencer (Member 1925) died July 4, 1956. A native of Long Branch, N. J., he graduated from Harvard University in 1895. Prior to becoming president of the Fruit Growers Express Co. and Western Fruit Express Co. he had supervised construction work for the Southern Railway System. In 1922 he was appointed U. S. Federal Fuel Distributor.

Oliver R. Taggart (Member 1938) died suddenly on Oct. 13, 1956, at the age of 69. A native of Salina, Kan., he graduated from the Colorado School of Mines in 1909. In 1915, he joined the National Lead Co. plant of St. Louis Smelting & Refining Co.

(Continued on page 477)

Necrology

Date Elected	Name	Date of Death
1917	D. Avery	October 1956
	Life Member	
1951	Samuel J. Beckman	Nov. 16, 1956
1949	John H. Emrick	Unknown
1904	Stephen L. Goodale	Jan. 17, 1957
	Legion of Honor	
1928	James M. Hall	Feb. 4, 1953
1953	Walter C. Haus	Feb. 3, 1957
1908	E. A. Holbrook	Feb. 20, 1957
1928	R. C. Holmes	Unknown
1955	J. D. Phillips	Feb. 27, 1956
1925	George Brown Pryde	Aug. 21, 1956
1920	John Lyon Rich	Unknown
1916	William A. Rigby	Jan. 19, 1957
1940	Willard T. Rogers	July 10, 1956
1945	Edwin B. Royle	Jan. 30, 1957
1956	Edward Scott, Jr.	Nov. 28, 1956
1939	M. I. Signer*	Nov. 17, 1956
1952	F. A. Vandestrick	Unknown

* M. I. Signer was incorrectly listed on the Necrology list, February 1957 MINING ENGINEERING, as M. I. Signer, Jr.

Appraisals
Professional Services
Geophysicists
Drilling

MEMBERSHIP

Proposed for Membership
Society of Mining Engineers of AIME

Total AIME membership on Jan. 31, 1957, was 26,903; in addition 2,493 Student Associates were enrolled.

ADMISSIONS COMMITTEE

R. B. Caples, Chairman; F. A. Ayer, Vice-Chairman; A. C. Brinker, R. H. Dickson, C. R. Dodson, R. B. Fulton, T. D. Jones, F. W. Hanson, Sidney Rolfe, F. T. Sisco, O. B. J. Fraser, F. W. McQuiston, Jr., A. R. Lytle, L. P. Warriner.

The Institute desires to extend its privileges to every person to whom it can be of service, but does not desire as members persons who are unqualified. Institute members are urged to review this list as soon as possible and immediately to inform the Secretary's office if names of people are found who are known to be unqualified for AIME membership.

Members

Ralph M. Barnard, Grand Junction, Colo.
Dhirendra Kumar Basu, Bihar, India
Hans A. Bauer, Atlanta
D. G. Brubaker, Palmerton, Pa.
P. Callais, Mulhouse, France
D. S. Campbell, Riondel, B. C., Canada
Lloyd S. Campbell, Duluth
H. E. Collins, London, England
James T. Curry, San Andreas, Calif.
Howard M. Dorward, Denver
Thomas B. Douglas, Denver
Ed. T. Dwyer, Moab, Utah
D. I. Foust, Jr., Birmingham
Roy M. Frisen, Los Angeles
Richard H. Gemmill, Jerome, Ariz.
Lester S. Heybourne, Cedar City, Utah
Don Jenkins, Austinville, Va.
Herbert B. Johnson, Clearwater, Fla.
Richard W. Lee, Morgantown, W. Va.
Hugh B. Lynch, Sunrise, Wyo.
Nestor O. Montero, Manila, P. I.
J. H. Moore, Transvaal, South Africa
G. W. Neumann, Durango, Mexico
Marion H. Nicholson, Tucson, Ariz.
Ellis A. Robinson, Silver Bell, Ariz.
Ross V. Seeton, Jr., Grand Junction, Colo.
K. P. Singh, Bihar, India
S. E. Sullivan, Birmingham
C. P. Tremlett, Ouray, Colo.
P. E. Waugh, Kuala Lumpur, Malaya
K. E. Zachos, New York
C. F. Zahnow, Mexico City, Mexico

Associate Members

John P. Bagoy, Anchorage, Alaska
W. F. Carter, Mulberry, Fla.
W. C. Flinn, Saint Paul
William L. Fornwald, Dalton, Pa.
Lewis G. Hersey, Salt Lake City
Arthur L. Keswick, Moab, Utah
W. L. Lilley, Lima, Peru
Charles F. Osgood, Franklin, Pa.
Harry Thornton, New York
Mark Leonard Ward, Idria, Calif.
Elmer Wilson, Eureka, Calif.

Junior Members

Salvatore Anthony Anzalone, Roslyn Heights, N. Y.
Byrd L. Berman, Forrest Hills, N. Y.
R. C. Bryant, Miami, Ariz.
Dale Harold Carlson, Albuquerque, N. M.
A. Davila, Barcelona, Venezuela
William A. Hockings, Calumet, Mich.
R. Steensma, Delft, Holland
Gerald Stoocks, Moab, Utah
F. G. Van der Hoeven, San Francisco
Roy J. York, Jr., Malvern, Ariz.

CHANGE OF STATUS

Associate to Member

Arthur Baker III, Gunnison, Colo.
Lloyd D. Brownson, Twin Falls, Idaho
Alexander W. Calder, Franklin, Pa.
Jack E. Nelson, Jefferson City, Tenn.
R. R. Williams, St. Ann, Jamaica, B. W. I.

Junior to Member

Richard H. Kennedy, Bethesda, Md.
Gerald J. Miatech, Dayton
Richard V. Wyman, St. George, Utah

REINSTATEMENT

Members

Wilbur John Cook, La Serena, Chile
N. A. Fittinghoff, Manila, P. I.
W. D. Mateer, Golden, Colo.

REINSTATEMENT—CHANGE OF STATUS

Associate to Member

Warren D. Sharpenberg, Morgantown, W. Va.

Junior to Member

Jones R. Castro, Quezon City, P. I.
H. R. Swingle, San Francisco

Student to Member

Cleon R. Fowler, Morgantown, W. Va.

Student to Associate

John Radomsky, Peoria, Ill.

Student to Junior

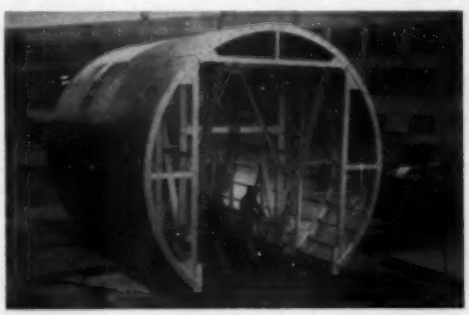
Gordon Deutsch, New Orleans
Pierce D. Baker, Salt Lake City

Obituaries

(Continued from page 476)

in Collinsville, Ill., as chemist, and remained with the former company as smelter superintendent until 1937. From 1935 to 1937, and again in 1940, he worked for the National Lead Co. in Buenos Aires, Argentina.

Theodore C. Wiedenhoefer (Member 1952) died July 24, 1956, in Butte, Mont. Born in Hubbell, Mich., on Jan. 29, 1894, Mr. Wiedenhoefer was a graduate of Michigan College of Mining and Technology. He joined Nordberg Manufacturing Co., Milwaukee, in 1922 as an erecting engineer and held many subsequent posts at the company, including sales engineer and superintendent of the Navy shop for the duration of the war. In 1946, he was named manager of the mine hoist department. Prior to his association with Nordberg, he had been an efficiency engineer for Calumet and Hecla Mining Co., and was an instructor at Oklahoma School of Mines, Miami, Okla.



MAYO STEEL FORMS
SPEED TUNNEL JOBS
IN THE PHILIPPINES*

*5.2 Diameter Tunnel—Invert Last Ambuklao Project

Mayo produces all types of Tunnel Forms—telescopic, non-telescopic, separate sidewall and arch, single unit, full round forms for monolithic pours, etc. Each is designed for the exact requirements of the job in any part of the world—be it tunnel, sewer or conduit.

Write for FREE Bulletin No. 22 or send details.

MAYO
TUNNEL & MINE EQUIPMENT
LANCASTER, PA.

Steel Forms
Headframes
Muck Bins
Shields
Air Locks
Locomotives
Mine Cars
Grouters

Over
Half Century
Experience in

Exploration and Development
Diamond Core Drilling
Rock Breaking—Grouting
Shaft Sinking
Mining—Quarrying
and Tunnel Driving

Full details on request

Bowles Bros.
DRILLING COMPANY

1321 South Main St. • Dial HUnter 4-4401
Salt Lake City, Utah

Spokane, Washington	Telephone KE 4-0862 and WA 4-2614
Leadville, Colorado	Telephone 443-W
Phoenix, Arizona	Telephone CRestwood 4-5331
Monticello, Utah	Telephone 93R1 and 91R4
Reno, Nevada	Telephone FAirview 9-0732
Denver, Colorado	Telephone WEst 4-0673
Alaska	Contact Salt Lake City Office

Appraisals
Assayers
Chemists
Construction
Consulting
Designing

Professional Services

Space limited to AIME members or to companies that have at least one member on their staffs. One inch, $40 per year; half inch, $25 payable in advance.

Geophysicists
Drilling
Management
Metallurgical
Reports
Valuations

ADAIR, BAILEY & VAN HORN
Minerals Consultants
Geology Mining Ore Dressing
Box 221, Murphy, N. C.

SIDNEY S. ALDERMAN, JR.
Consulting Geologist
814 Newhouse Building
Salt Lake City 11, Utah
Telephone: ELgin 9-0976

JAMES A. BARR
Consulting Engineer
Mt. Pleasant, Tennessee

Philip J. Baukol
DESIGNER OF PLANTS
INDUSTRIAL • METALLURGICAL

BEHRE DOLBEAR & COMPANY
Consulting Mining Engineers and Geologists
11 Broadway New York 4, N. Y.

PHILIP B. BROWN
Mexico
Mine Sampling & Economic Reports
Ave de las Quintas No. 20 Tel 307
Parral, Chih., Mexico

BLANDFORD C. BURGESS
Registered Professional Engineer
Mining Consultant
Monticello, Georgia

COWIN & COMPANY, INC.
Mining Engineers and Contractors
Shaft & Slope Sinking • Mine Development
Mine Plant Construction
1-18th Street SW,
Birmingham, Ala. Phone 56-5566

D. H. ELLIOTT
MINING PHOTOGEOLOGIST
P. O. Box 1007 Casper, Wyoming

DAVID LeCOUNT EVANS
Consultant
Mining Geology Petroleum Geology
314 Brown Bldg. Wichita, Kansas
Tel.: AMherst 2-8954 or MUrray 3-6437

HOWARD M. FOWLER
MINING ENGINEER
P.Eng.: British Columbia & Alaska
408 Rogers Bldg. • Vancouver, B. C.
Telephone: Tatlow 0729
Aircraft — Scintillometer equipped

CARLTON D. HULIN
Mining Geology
7 Ardilla Road Orinda, California

GUY E. INGERSOLL
Registered Professional Engineer in Texas, Arizona and New Mexico
Mine Examinations and Geological Reports
5505 Timberwolf Drive El Paso, Texas

C. PHILIP JENNEY
Consulting Geologist
372 Lakeshore Hy. W.
Oakville Ontario
Victor 4-9413

PHILIP L. JONES
Consultant
Mineral Economics & Mineral Dressing
Heavy Media Specialist
405 Miners Bank Bldg. Joplin, Mo.
Tel. MAyfair 3-7161

RAPHAEL G. KAZMANN
Consulting Ground-Water Engineer
Stuttgart, Arkansas

C. P. KEEGEL
Mining and Metallurgical Engineer
Administration Appraisal
Specializing in Management and Consultation in Latin America
1721 So. 14th St., Las Vegas, Nevada
Telephone DUdley 4-6981

KELLOGG EXPLORATION COMPANY
Geologists-Geophysicists
Air, Ground Surveys and Interpretation
3301 No. Marengo, Altadena, Calif.
Sycamore 4-1973

KELLOGG KREBS
Mineral Dressing Consultant
564 Market St., San Francisco 4, Calif.

KIRK & COWIN
Consulting • *Appraisals* • *Reports*
1-18th Street SW,
Birmingham, Ala. Phone 56-5566

LEDOUX & COMPANY
Chemists Assayers Spectroscopists
SHIPPERS REPRESENTATIVES
Mine Examination Analyses
359 Alfred Ave. Teaneck, New Jersey

JOSEPH T. MATSON
CONSULTING MINING ENGINEER
Examinations—Appraisals Operations
P. O. Box 170 Santa Fe, New Mexico

CLAYTON T. McNEIL, E. M.
Consulting Mining Engineer
822 Bank of America Bldg.
Tel. GArfield 1-2948
SAN FRANCISCO 4, CALIFORNIA

ARNOLD B. MILLER
Consulting Engineer
Mine, Mill and Industrial Investigations
Improvement Design and Recommendations
Cable: "ALMIL" Tel. Cortlandt 7-0635
120 Broadway New York 5, N. Y.

O'DONNELL & SCHMIDT
Mining Consultants
165 Broadway Tel. BArclay 7-6960
New York 6, N. Y. Cables: EXAMIMINES

AMEDEE A. PEUGNET
CONSULTING MINING ENGINEER
Telephone MAIN 1-1431
705 Chestnut St. St. Louis 1, Mo.

LUCIUS PITKIN, INC.
Mineralogists
Assayers—Chemists—Spectroscopists
Shippers' Representatives
PITKIN BLDG., 47 FULTON ST., NEW YORK
Cable Address: Niktip

MILNOR ROBERTS *Consulting Mining Engineer*
The Pacific Northwest,
British Columbia and Alaska
4501 15th Ave., N.E. Seattle, Wash.

WILLIAM J. SHEDWICK, JR.
Mine and Geologic Reports
Mexico and Latin America
New Jersey License 2744-a
Reforma 20-302 Mexico 1, D.F.

CLOYD M. SMITH
Mining Engineer
Mine Examinations
Ventilation Surveys
Munsey Building Washington 4, D.C.

LEO H. TIMMINS, P. Eng.
MINING ENGINEER
Examinations - Reports
Financing of Prospects
Suite 700 1980 Sherbrooke, Montreal
Phone Gleaview 2376

GODFREY B. WALKER
Metallurgical Consultant
Mineral Dressing & Extractive Metallurgy
Heavy Media a Specialty
27 Lockwood Drive Old Greenwich, Conn.

O. W. WALVOORD CO.
Mill-Design and Construction
401 High St. Denver 3, Colo.

CLIFFORD R. WILFLEY
Consulting Mining Engineer
2233 Grape St. Denver 7, Colorado

CLYDE H. WILSON
MINING ENGINEER AND GEOLOGIST
Registered Professional Engineer
GEOLOGICAL & GEOPHYSICAL SURVEYS
Mineral Deposits • Petroleum
Ground Water
366 South Fifth East, Salt Lake City 2, Utah

HARRY J. WOLF
Mining and Consulting Engineer
Examinations—Valuations—Management
One Park Place, New York 7, N. Y.
Cable: MINEWOLF Tel. Rector 2-5307

NEWELL G. ALFORD
Consulting Mining Engineer
Coal Property Prospecting, Development, Operation and Valuation
Oliver Building Pittsburgh 22, Pa.

ALLEN & GARCIA COMPANY
42 Years' Service to the Coal and Salt Industries as Consultants, Constructing Engineers and Managers
Authoritative Reports and Appraisals
332 S. MICHIGAN AVE., CHICAGO
120 WALL ST., NEW YORK CITY

BALL ASSOCIATES
Oil, Gas and Minerals Consultants
Douglas Ball Wendell W. Fertig
R. H. Fulton Alan M. Bieber
A. S. Wyner
Offices
1025 Vermont Ave. C. A. Johnson Bldg.
Washington, D. C. Denver, Colo
STerling 3-1929 ALpine 5-4878

B. B. R. DRILLING CO.
National Road West
St. Clairsville, Ohio
Diamond Core Drilling Contractors
Mineral Cores Guaranteed
Foundation Testing

CENTENNIAL DEVELOPMENT CO.
Consulting Mining Engineers and Contractors
Shaft Sinking — Tunnel Driving
Mine Development
Eureka, Utah Phone 560

EAVENSON, AUCHMUTY & SUMMERS
MINING ENGINEERS
Mine Operation Consultants
Coal Property Valuations
2720 Koppers Bldg. Pittsburgh 19, Pa.

MAC AFEE and COMPANY
Consulting Engineers
MINE EXAMINATION & MILL DESIGN
Exploration - Construction
Operation & Management
CHEMICAL & METALLURGICAL LABORATORY
FOR EXACT QUANTITATIVE FLOWSHEET DATA
3105 Wilshire Boulevard - Los Angeles 5
DUnkirk 8-9474 - CABLE MACAFEE

FAIRCHILD AERIAL SURVEYS, INC.
Airborne Magnetometer & Gradiometer Surveys, Topographic Mapping, Aerial Photography, and Photographic Mosaics for Mining Exploration.
224 E. 11th St. Los Angeles
30 Rockefeller Plaza New York

THERON G. GEROW
MINING CONSULTANT AND ENGINEER
111 North Wabash Avenue
Chicago 2, Illinois

GRAFF ENGINEERING COMPANY
Mining Engineers and Surveyors
39 E. Campbell St. Blairsville, Pa.

ABBOT A. HANKS, Inc.
ASSAYERS-CHEMISTS
Shippers Representatives
624 Sacramento Street
SAN FRANCISCO

JOHN D. HESS
Consulting Ground-Water Geologist
- Investigations
- Reports
- Geochemical Studies
- Electrical Logging
- Drainage Surveys
- Water Supply

Complete Physical-Chemical Laboratory Facilities
EL CENTRO, CALIFORNIA

HOPKINS EXPLORATION CONSULTANTS
607-320 Bay St. Toronto 1
EM. 4-5642 HU. 9-8375
Branches
Algoma Mills and Timmins, Ont.
Uranium City, Saskatchewan

DIAMOND CORE DRILLING BY CONTRACT
and world's largest manufacturer
Core and grout hole drilling in coal, metal, and non-metallic deposits, both surface and underground.
JOY MANUFACTURING CO.
Contract Core Drill Division
Michigan City, Indiana

KNOWLES ASSOCIATES
Chemical - Metallurgical - Mechanical
ENGINEERS
URANIUM ORE PROCESSING
ECONOMIC STUDIES - MILL DESIGN
19 RECTOR ST. NEW YORK (6) N. Y.

LEGGETTE, BRASHEARS & GRAHAM
Consulting Ground-Water Geologists
Water Supply, Dewatering, Recharging
Salt Water Problems, Investigations, Reports
551 Fifth Avenue, New York 17, N. Y.

ROBERT S. MAYO
Civil Engineer Lancaster, Pa.
Specializing in Concrete Lining of Tunnels, Haulageways and Shafts. Special Equipment for Subaqueous Construction.

E. J. LONGYEAR COMPANY
Geological and Mining Consultants
Mineral Exploration and Appraisals
Photogeology
Foshay Tower, Mpls. 2, Minn.
Graybar Bldg. N. Y. 17, N. Y.
Colorado Bldg. Denver 2, Colo.
Shoreham Bldg. Wash. 5, D. C.

R. S. MC CLINTOCK DIAMOND DRILL CO.
Spokane, Wash. — Globe, Ariz.
Diamond Core Drill Contractors
Manufacturers of Diamond Bits and Drilling Accessories

JOHN F. MEISSNER ENGINEERS, INC.
Consulting Engineers
Conveyor Systems Storage Methods
Crushing Plants Ship Loading Docks
Materials Handling and Processing Plants
308 W. Washington St. Chicago 6, Ill.

JOHN D. MORGAN, JR., E. M., PH. D.
Consultant
Business and Defense Problems in Metals, Minerals, and Fuels
724 14th St., N.W., Washington 5, D.C.
ME 8-1681

J. B. MORROW
COAL CONSULTANT
Oliver Bldg. Pittsburgh, Pa.

DIAMOND CORE DRILLING CONTRACTORS
Testing Mineral Deposits
Foundation Borings
MOTT CORE DRILLING CO.
Huntington, W. Va.

Frank M. Murphy & Associates, Inc.
DESIGN & CONSTRUCTION ENGINEERS
Specializing in Material Handling Mining Mineral Beneficiation & Chemical Processing
Wesley M. Houston J. D. Raulerson, Jr. John C. Yost
Box 271 Bartow, Fla.

PENNSYLVANIA DRILLING COMPANY
PITTSBURGH 20, PA.
DRILLING CONTRACTORS and MANUFACTURERS
We prospect coal and mineral land anywhere in North and South America. Core borings for foundation testing; dams, bridges, buildings, etc.

PRODUCTION AND MANAGEMENT SPECIALIST
ROGER V. PIERCE
Underground Mining Methods, Cost Cutting Surveys—Production Analysis —Mine Mechanization—Mine Management.
808 Newhouse Bldg. EMPIRE 3-5373
Salt Lake City 4, Utah

SHENON AND FULL
Consulting Mining Geologists
1351 South 2200 East
Salt Lake City 8, Utah
Telephone HUnter 4-7251
Philip J. Shenon Roy P. Full

M. G. SMERCHANSKI
Consulting Mining Geologist
Registered Professional Engineer
Examinations, Geological Surveys & Development
411 Childs Bldg. Winnipeg, Manitoba
Phone: 926323

SPRAGUE & HENWOOD, Inc.
SCRANTON 2, PA.
Diamond Drill Contractors and Manufacturers
Core borings for testing mineral deposits in any part of the world.

STILL & STILL
Consulting Mining Engineers and Geologists
24 Union Block — Phone 658
P.O. Box 1512
Prescott, Arizona

H. L. TALBOT
Consulting Metallurgical Engineer
Extraction and Refining of Base Metals Specializing in Cobalt and Copper
Room 330, 84 State Street
Boston 9, Mass.

F.C. TORKELSON CO.
ENGINEERS
Industrial Plant Design
Process Development Estimates
Economic Studies Plant Layout
146 South West Temple
SALT LAKE CITY 1, UTAH

PAUL WEIR COMPANY
Mining Engineers and Geologists
Consultants and Managers
Design and Construction
20 No. Wacker Drive Chicago 6, Ill.

J. W. WOOMER & ASSOCIATES
Consulting Mining Engineers
Modern Mining Systems and Designs
Foreign and Domestic Mining Reports
Henry W. Oliver Bldg., Pittsburgh, Pa.

WORLD MINING CONSULTANTS, INC.
Consulting Mining Engineers and Geologists
220 Broadway, New York 38, N. Y.
Worth 2-2934

Coming Events

Apr. 5, 6, AIME Pacific Southwest Mineral Industry Conference. Sponsored by Nevada Section, cosponsored by San Francisco and Southern California Sections. Reno.

Apr. 8-10, AIME, National Open Hearth Steel and Blast Furnace, Coke Oven, and Raw Materials Conferences, Penn-Sheraton Hotel, Pittsburgh.

Apr. 10, AIME Utah Local Section, AIME Student Section, University of Utah, dinner meeting. Speaker: A. B. Kinzel, AIME President-Elect; subject: *The New Elements.* Union Hall, University of Utah, Salt Lake City.

Apr. 11-13, AIME, Pacific Northwest Regional Conference, Multnomah Hotel, Portland, Ore.

Apr. 21-24, Second Annual Symposium on Rock Mechanics, Sponsored by Colorado School of Mines, Golden, Colo.

Apr. 22-24, CIM, annual meeting, Ottawa, Ont., Canada.

Apr. 24-25, Lead Industries Assn., annual meeting, Drake Hotel, Chicago.

Apr. 25-26, American Zinc Inst. Inc., 30th annual meeting, Drake Hotel, Chicago.

May 6-8, Institute on Lake Superior Geology, annual meeting, cosponsored by AIME Exploration Subsection, Upper Peninsula Local Section, Michigan Geological Survey, and Michigan Geological Society. Kellogg Center, Michigan State University, East Lansing, Mich.

May 13-16, Coal Convention and Exposition of the American Mining Congress, City Auditorium, Cleveland.

May 16, AIME Utah Local Section. Speaker: A. E. Millar, General Manager, The Anaconda Co., Yerington Mines, Weed Heights, Nev.; subject: *The Yerington Story.* Newhouse Hotel, Salt Lake City.

May 16-18, Geological Soc. of America, Southwestern Section meeting, Morgantown, W. Va.

May 23-24, Lake Superior Mines Safety Council, 33rd annual conference, Hotel Duluth, Duluth.

May 24-25, AIME Central Appalachian Section, spring meeting, Maple Shade Inn, Pulaski, Va.

June 16-21, ASTM, annual meeting, Chalfonte-Haddon Hall Hotel, Atlantic City, N. J.

Sept. 5-7, New Mexico Geological Soc., 8th annual field conference, Durango-Silverton-Ouray area, southwestern Colorado.

Sept. 8-Oct. 9, Commonwealth Mining and Metallurgical Congress, British Columbia to Nova Scotia, Canada.

Sept. 9-12, American Mining Congress, annual convention, Utah and Newhouse Hotels, Salt Lake City.

Sept. 18-21, International Mineral Dressing Congress, Royal Inst. of Technology, Stockholm, Sweden.

Oct. 6-9, AIME, Petroleum Branch, Dallas.

Oct. 9-11, ASME-AIME Coal Div., Joint Solid Fuels Conference, Chateau Frontenac, Quebec.

Oct. 15-18, Southeastern Mining Conference, Hillsboro Hotel, Tampa, Fla.

Oct. 30-Nov. 1, AIME, Rocky Moutain Minerals Conference, Denver.

Nov. 4-6, AIME, IMD Fall Meeting, Morrison Hotel, Chicago.

Nov. 11-14, Society of Exploration Geophysicists, 27th Annual Meeting, Statler-Hilton Hotel, Dallas.

Dec. 1-6, ASME, Annual Meeting, Hotel Statler, New York.

Dec. 4-6, AIME, Electric Furnace Steel Conference, Penn-Sheraton Hotel, Pittsburgh.

Feb. 16-20, 1958, AIME Annual Meeting, Hotel Statler, New York.

Advertisers Index

Allis-Chalmers Mfg. Co., Construction Machinery Div. — 383
Bert S. Gittins Adv., Inc.

Allis-Chalmers Mfg. Co., Industrial Equipment Div. — 404, 405, 412A, 412B
Compton Adv. Inc.

American Brattice Cloth Corp. — *
Tri-State Adv. Co., Inc.

American Cyanamid Co. — 420A
James J. McMahon, Inc.

American Manganese Steel Div., American Brake Shoe Co. — 416
Fuller & Smith & Ross, Inc.

Anaconda Co., The — *
Kenyon & Eckhardt, Inc.

Armour & Co. — 388, 389
Foote, Cone & Belding

Athey Products Corp. — 412
Thomson Adv., Inc.

Atlas Copco Aktiebolag (Sweden) — *
Intam Limited

Bin-Dicator Co. — 475
Clark & Bobertz, Inc.

Boyles Bros. Drilling Co. — 477
Adamson, Buchman & Associates

Bucyrus-Erie Co. — 396
Bert S. Gittins Adv.

Caterpillar Tractor Co. — 394
N. W. Ayer & Son, Inc.

Chain Belt Co. — 470
The Buchen Co.

Colorado Fuel & Iron Corp., The — 411
Doyle, Kitchen & McCormick, Inc.

Colorado Iron Works Co. — *
Walter L. Schump, Adv.

Dart Truck Co. — *
Carl Lawson Adv.

Deister Concentrator Co., Inc. — 474
Louis B. Wade, Inc.

Denver Equipment Co. — Third Cover
Galen E. Broyles Co., Inc.

DeZurik Corp. — *
The Stockinger Co.

Dorr-Oliver Inc. — 420B
Sutherland-Abbott Adv.

Dow Chemical Co., The — 391, 392, 393
MacManus, John & Adams, Inc.

Dow Corning Corp. — *
Church and Guisewite Adv. Inc.

Eimco Corp., The — 397, 399, 401
Matzie Co.

Equipment Engineers, Inc. — *
Norton M. Jacobs Adv.

Fate-Root-Heath Co., The, Plymouth Locomotive Works Div. — *
Howard Swink Adv.

Flexible Steel Lacing Co. — *
Kreicker & Meloan, Inc.

Gardner-Denver Co. — 421
The Buchen Co.

Hardinge Co., Inc. — 467
Adams Associates, Inc.

Harnischfeger Corp. — *
Fuller & Smith & Ross, Inc.

Hercules Powder Co. (Explosives) — 398
Fuller & Smith & Ross, Inc.

Hewitt-Robins, Inc. — 390
Fuller & Smith & Ross Inc.

Hoffman Bros. Drilling Co. — 472
Hewitt Adv.

Hough Co., The Frank G. — 414, 415
Ervin R. Abramson Adv.

Humphreys Investment Co. — *
Ed M. Hunter & Co.

Ingersoll-Rand Co. — 384
Marsteller, Rickard, Gebhardt & Reed Inc.

International Nickel Co., Inc. — 402
Marschalk & Pratt

Jeffrey Mfg. Co. — *
The Griswold-Eshleman Co.

Joy Mfg. Co. — 406
W. S. Walker Adv. Inc.

Kennametal Inc. — 382
Ketchum, MacLeod & Grove, Inc.

Kennedy-Van Saun Mfg. & Engrg. Corp. — 408, 409
Rea, Fuller & Co., Inc.

Le Roi Division Westinghouse Air Brake Co. — 400
Hoffman & York, Inc.

LeTourneau-Westinghouse Co. — *
Andrews Agency, Inc.

Longyear Co., E. J. — *
Savage-Lewis, Inc.

Mace Co. — *

Mayo Tunnel & Mine Equipment — 477
The Godfrey Agency

Metal Carbides Corp. — *
Meek and Thomas, Inc.

Mine & Smelter Supply Co. — 420
Walter L. Schump, Adv.

Mine Safety Appliances Co. — Fourth Cover
Ketchum, MacLeod & Grove, Inc.

Nagle Pumps, Inc. — *
Tri-State Adv. Co., Inc.

Naylor Pipe Co. — *
Fred H. Ebersold, Inc.

Nordberg Mfg. Co. — 387
Russell T. Gray, Inc.

Northern Blower Co. — 469
Carr Liggett Adv., Inc.

Sanford-Day Iron Works, Inc. — *
Charles S. Kane Co.

Sauerman Bros. Inc. — *
Symonds, MacKenzie & Co.

Sharples Corp. — *
Renner Advertisers

Sheffield Steel Co. — 385
Potts • Woodbury, Inc.

Smidth & Co., F. L. — *
The Stuart Co.

Spencer Chemical Co. — *
Bruce B. Brewer & Co.

Sprague & Henwood, Inc. — 473
Anthracite Adv.

Stearns-Roger Mfg. Co. — *
Mosher-Reimer-Williamson Adv. Agency, Inc.

Syntron Company — 471
Servad, Inc.

Texas Gulf Sulphur Co. — 413
Sanger-Funnell, Inc.

Thor Power Tool Co. — *
Roche, Williams & Cleary, Inc.

Traylor Engrg. & Mfg. Co. — 417
The William B. Kamp Co.

Tyler Co., W. S. — 386

Western Machinery — 410
Boland Associates

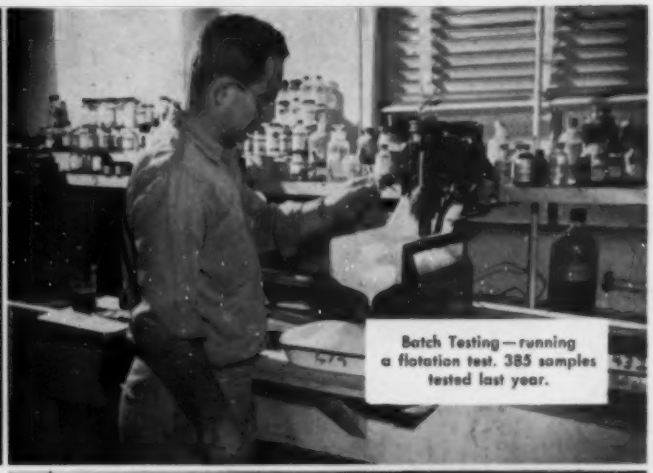
Wilfley & Sons, Inc., A. R. — Second Cover
Ed M. Hunter & Co.

Wilkinson Rubber Linatex, Ltd. — *
Greenlys Ltd.

Yuba Mfg. Co. — *
Geo. C. McNutt Adv.

* Previous Issues

DENVER ORE TESTING



Batch Testing—running a flotation test. 385 samples tested last year.

ASSURES MINE PROFITS ...ELIMINATES RISKS

If you are building a new mill...or adding a new section...it will pay you to investigate the DECO "Better Way" of mill operation! Take the guesswork out of a big investment...and KNOW where you are going!

DECO engineers...with their many years of field, operating, design and laboratory experience...will test your ore...using the latest techniques and most modern equipment...and will inform you of the best and most economical way to process your ore.

Yes, it will pay you well to avail yourself of DECO's complete ORE TESTING services*...in time, money AND ore beneficiation!

**DECO's Ore Testing Division is operated as a non-profit service for the benefit of our customers.*

Clarence Thom heads the DECO Ore Testing Division and is but one of our many practical, experienced engineers who are ready and able to help you with your problems...TODAY!

Batch-Cyanidation testing—and determination of settling thickening rates.

Six cell "Sub-A" operating in pilot plant. Treating a talc ore. These facilities available for your use, your engineers or ours.

"The firm that makes its friends happier, healthier and wealthier"

DECO ENGINEERED — DENVER EQUIPMENT 24 HOUR SERVICE COMPANY

DENVER EQUIPMENT CO.

1400 Seventeenth St. • Denver 17, Colorado

DENVER • NEW YORK • CHICAGO • VANCOUVER • TORONTO
MEXICO, D. F. • LONDON • JOHANNESBURG

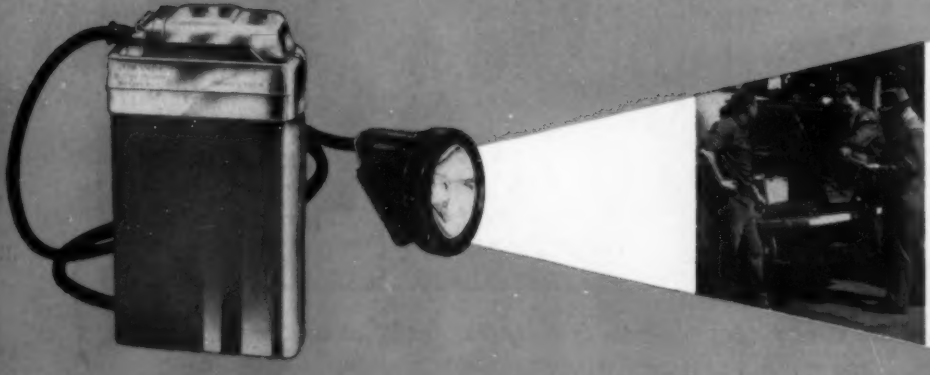
You can depend on the EDISON R-4's brilliant, unfailing light...

The Bulb's reserve filament means continued, full light

See the double filament in the bulb? It's your proved protection against lost time for the miner, and a short crew for the foreman. If one filament burns out, a turn of the switch restores continued, brilliant, full illumination—*working light*, not just emergency light!

The battery that doesn't fail on the job

Because light is only as dependable as the battery that provides the power, battery service life is the only answer to performance. The Edison R-4 Battery does not destroy itself to function, does not deteriorate when not in use. You get the most dependable light, shift-after-shift, for years.



The M.S.A. Service Engineer makes your lighting his business

Your Edison lamp installation—Self-Service, Standard or Modified—is the responsibility of a trained M.S.A. Service Engineer. His planned system of return calls insures your receipt of the maximum service from your lamps. You benefit from this responsible know-how in peak lamp performance, more efficient and economical lamphouse procedure.

MSA
SAFETY EQUIPMENT HEADQUARTERS

When you have a safety problem, M.S.A. is at your service . . . our job is to help you

MINE SAFETY APPLIANCES CO.
201 North Braddock Avenue, Pittsburgh 8, Pa.
At Your Service: 77 Branch Offices in the United States and Mexico
MINE SAFETY APPLIANCES CO. OF CANADA, LTD.
Toronto, Montreal, Calgary, Edmonton, Winnipeg, Vancouver, Sydney, N.S.

These Edison R-4 QUALITY features, and service, give you that *extra* illumination that lets you realize every production advantage from today's mechanized equipment. Let us show you how this vital mining tool can help fill the gap between average and peak production with greater safety. Write for details.